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Digital modulation method.

(g) A digital modulation method for modulating 8-bit digital data into 14-bit digital modulation codes. The number of consecutive identical bits in a series of 14-bit digital modulation codes is restricted to 2 - 7. The absolute value of DSV at the end of each 14-bit digital modulation code is restricted to 2 or less, and the absolute value of DSV at each bit of any 14-bit digital modulation codes is limited to 7 or less. The direct current component of the 14-bit modulation codes can be effectively reduced.



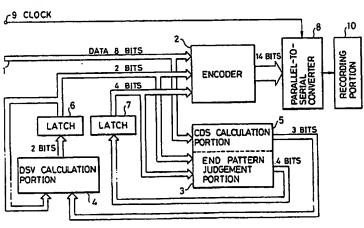


FIG.1

DIGITAL MODULATION METHOD

The present invention relates to a digital modulation method which converts 8-bit digital data into 14-bit digital modulation codes.

Conventional apparatuses, which use rotary heads to record digital data to magnetic tape or to reproduce digital data recorded on magnetic tape, utilize rotary transformers to record or reproduce the digital data: recording is performed by supplying the digital data to the rotary head through the rotary transformer; and reproduction is performed by reading the digital signal with the rotary magnetic head through the rotary transformer.

Consequently, if the reproduced signal includes a DC (Direct Current) component, the digital data cannot be correctly reproduced. For this reason, the digital data must be recorded by using a DC free digital modulation system.

Among the conventional DC free digital modulation systems, the following systems are well known.

The 8-10 modulation system, the DR (Density Ratio) of which is 0.8, is described in Japanese Patent Application Laying-Open No. 56-19506.

The M² modulation system, the DR of which is 1, is known.

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The 8-14 modulation system, the DR of which is 1.14, is described in Japanese Patent Application Laying-Open No. 61-196469. This system provides up to four 14-bit digital modulation codes for each 8-bit digital data. When the CDS (Code word Digital Sum) of a 14-bit modulation code is zero, the code is paired with the reversal pattern thereof. When the CDS of a 14-bit digital modulation code is not zero, the code is grouped with the following three codes: another 14-bit modulation code the absolute value and sign of CDS of which differ from those of the above code; and the reversal patterns of the respective codes.

Here, CDS is defined as a DSV calculated from the first bit to the last bit of a modulation code: DSV (Digital Sum Value) is a total sum obtained by adding -1 for respective bits "0" in a series of digital modulation codes and by adding 1 for respective bits "1" in the same codes. The reversal pattern is a pattern obtained by reversing each bit in a code: bit "1" is reversed to "0", whereas bit "0" is reversed to "1".

The above-mentioned conventional modulation systems have the following problems.

The 8-10 modulation system is not appropriate to a high-density recording because of its low DR of 0.8. The M² modulation system is restricted in its high density recording because of its DR of 1.

The 8-14 modulation system has up to 4 modulation codes for each 8-bit code, and the absolute value of CDS of the digital modulation codes are allowed up to 6. In addition, DSV at the end of each 14-bit digital modulation code in the code stream is allowed up to \pm 4, and DSV at each bit in a series of the 14-bit digital modulation codes is allowed up to \pm 9. Consequently, it is difficult to eliminate the DC component of the modulation codes in a short time, and hence, low frequency component must be adequately passed in a recording/reproducing system including the rotary transformer.

A further problem is presented in the 8-14 modulation system. Generally speaking, magnetizing depth on magnetic tape is about 1/4 of the magnetized wavelength. When recording signals are over-written on the tape, the following problem occurs: recording a new signal of the shortest magnetized wavelength on the longest magnetized wavelength which is 4 times or more longer than the shortest magnetized wavelength results in the erasing residue in the deeper part of the recording medium. This erasing residue appears during reproduction of the new signal, and so the over-writing is practically difficult.

Thus, the 8-14 modulation system suffers from the problem caused by the erasing residue when overwriting is performed because the number of consecutive identical bits ("0" or "1") in a 8-14 modulation code train is 2-9.

Incidentally, in the later description, the term "consecutive identical bits" means two or more consecutive identical bits: for example, "000" or "11".

It is therefore an object of the present invention to provide a digital modulation system which can solve the above problems: the digital modulation system that allows high density recording, that can reduce the DC component with high efficiency, and that can perform azimuth recording and over-writing.

In a first aspect of the present invention, there is provided a digital modulation method for converting 8-bit digital data into 14-bit digital modulation codes, the digital modulation method comprising:

step 1 for selecting up to four 14-bit digital modulation codes for each 8-bit digital data, the 14-bit digital modulation code is selected by the procedures of

(a) selecting among the 2¹⁴ 14-bit digital codes, a digital code the numbers of consecutive identical bits in which are 5 or less in the first 6 bits, 2 - 7 from the second bit to 13th bit, and 6 or less in the last 7 bits, the absolute value of CDS of the selected digital code being 4 or less, and repeating this selecting

procedure,

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- (b) selecting among the selected 14-bit digital codes at the procedure (a), a digital code the first bit of which is "0", and the value of CDS of which is 0, and pairing the selected 14-bit digital code with the reversal code thereof to make the 2 digital codes one group, or selecting among the selected 14-bit digital codes at the procedure (a), a digital code the first bit of which is "1", and the value of CDS of which is +2 or +4, combining the selected 14-bit digital codes with the reversal codes thereof, and further combining the two 14-bit digital codes with a pair of 14-bit digital codes selected at the above procedure to make the 4 digital codes one group, and repeating this selecting procedure,
- (c) selecting among the selected 14-bit digital codes at the procedure (a), a digital code the first bit of which is "0", and the value of CDS of which is +2, and another digital code the first bit of which is "1", and the value of CDS of which is +2 or +4, and combining the two selected 14-bit digital codes with the reversal codes thereof to make the 4 digital codes one group, and repeating this selecting procedure,
- (d) selecting among the selected 14-bit digital codes at the procedure (a), a digital code the first bit of which is "0", and the value of CDS of which is +4, and another digital code the first bit of which is "1", and the value of CDS of which is +2, and combining the two selected 14-bit digital codes with the reversal codes thereof to make the 4 digital codes one group, and repeating this selecting procedure, and
- (e) selecting 256 groups among the groups formed in the above procedures as the 14-bit digital modulation codes;
- step 2 for selecting one group of 14-bit digital modulation codes among the 256 groups of the 14-bit digital modulation codes, the selected group corresponding to inputted 8-bit digital data;
- step 3 for further selecting one or more 14-bit digital modulation codes in the selected group at step 2, each of the 14-bit digital modulation codes satisfying the requirement that the number of consecutive identical bits at the joint portion of the preceding 14-bit digital modulation code already selected and the 14-bit digital modulation code to be selected is 2 7; and
- step 4 for further selecting one 14-bit digital modulation code among the selected modulation codes at step 3 so that the one 14-bit digital modulation code satisfies the requirement that the absolute value of the DSV at each bit of the modulation code (called bit DSV hereinafter) is equal to or less than 7.
- In a second aspect of the present invention, there is provided a digital modulation method for converting 8-bit digital data into 14-bit digital modulation codes, the digital modulation method comprising:
- step 1 for selecting up to four 14-bit digital modulation codes for each 8-bit digital data, the 14-bit digital modulation code is selected by the procedures of
- (a) selecting among the 2¹⁴ 14-bit digital codes, a digital code the numbers of consecutive identical bits in which are 6 or less in the first 7 bits, 2 7 from the second bit to 13th bit, and 5 or less in the last 6 bits, and repeating this selecting procedure,
- (b) selecting among the 14-bit digital codes selected at the procedure (a), a digital code the first bit of which is "0", and the CDS of which has the absolute value equal to or less than 6, and repeating this selecting procedure,
- (c) selecting among the 14-bit digital codes selected at the procedure (a), a digital code the first bit of which is "1", and the CDS of which has the absolute value equal to or less than 4, and repeating this selecting procedure,
- (d) selecting among the 14-bit digital codes selected at the procedure (b), a digital code the value of CDS of which is 0, and pairing the selected 14-bit digital code with the reversal code thereof to make the 2 digital codes one group, and repeating this selecting procedure,
- (e) selecting among the 14-bit digital codes selected at the procedure (b), a digital code the value of CDS of which is +2, +4 or +6, selecting among the 14-bit digital codes selected at the procedure (c), a digital code the value of CDS of which is +2 or +4, and combining the two selected 14-bit digital codes with the reversal codes thereof to make the 4 digital codes one group, and repeating this selecting procedure, and
- (f) selecting 256 groups among the groups formed in the above procedures as the 14-bit digital modulation codes;
- step 2 for selecting one group of 14-bit digital modulation codes among the 256 groups of the 14-bit digital modulation codes, the selected group corresponding to inputted 8-bit digital data;
- step 3 for further selecting one or more 14-bit digital modulation codes in the selected group at step 2, each of the 14-bit digital modulation codes satisfying the requirement that the number of consecutive identical bits at the joint portion of the preceding 14-bit digital modulation code already selected and the 14-bit digital modulation code to be selected is 2 7; and
- step 4 for further selecting one 14-bit digital modulation code among the selected modulation codes at step 3 so that the one 14-bit digital modulation code satisfies the requirement that the absolute value of

the bit DSV of the modulation code is equal to or less than 8.

Fig. 1 is a block diagram showing a digital modulation apparatus for carrying out the digital modulation according to the first embodiment of the digital modulation method of the present invention;

Fig. 2 is a block diagram showing an embodiment of the decoding circuit;

Fig. 3A is a graph showing a carrier-to-noise ratio of a reproduced signal;

Fig. 3B is a graph showing a power spectrum of the first embodiment of the present invention;

Fig. 3C is a graph showing a power spectrum of the scrambled NRZ;

Fig. 4 is a view showing the number of 14-bit digital modulation codes whose CDS ≥ 0;

Fig. 5 is a view showing the number of 14-bit digital modulation codes whose CDS ≤ 0;

Fig. 6 is a block diagram showing a digital modulation apparatus for carrying out the digital modulation according to the second embodiment of the digital modulation method of the present invention;

Fig. 7 is a flowchart showing the modulation procedure of the digital modulation apparatus for carrying out the digital modulation according to the second embodiment;

Fig. 8 is a view showing the number of 14-bit digital modulation codes whose CDS ≥ 0; and

Fig. 9 is a view showing the number of 14-bit digital modulation codes whose CDS ≤ 0.

The invention will now be described with reference to the accompanying drawings.

[A] FIRST EMBODIMENT

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Fig. 1 is a block diagram showing a digital modulation apparatus for carrying out the digital modulation according to the first embodiment of the digital modulation method of the present invention.

In Fig. 1, 8-bit digital data 1 is converted to a 14-bit digital modulation code by an encoder 2. An end pattern judgement portion 3 converts the end pattern of the last 6-bits of the 14-bit digital modulation code into a 4-bit code in Table 9 (although the last 8 bits of the modulation codes are given in Table 9, only the last 6 bits should be considered). A CDS calculation portion 5 computes the CDS of the 14-bit digital modulation code supplied, and converts the resultant CDS into a 3-bit code in Table 7. A DSV calculation portion 4 adds the CDS of the current 14-bit digital modulation code to the DSV at the end of the preceding 14-bit digital modulation code, yielding a new DSV, and converts the new DSV into a 2-bit code shown in Table 8.

A parallel-to-serial converter 8 converts the 14-bit digital modulation code into a serial signal in synchronism with a clock signal 9. A recording portion 10 records the serial modulation signal produced from the parallel-to-serial converter 8 on a recording medium such as magnetic tape or the like.

TABLE 7

CDS of modulation codes	Corresponding 3-bit codes
-4	000
-2	001
0	010
2	011
. 4	100

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TABLE 8

DSV at the end of the preceding modulation codes	Corresponding 2-bit codes
-2	00
0	01
2	10

TABLE 9

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End pattern of the preceding modulation code	Corresponding 2-bit codes
xxxxx110	0000
xxxx1100	0001
xxx11000	0010
xx110000	0011
x1100000	0100
11000000	0101
xxxxx001	0110
xxxx0011	0111
xxx00111	1000
xx001111	1001
x0011111	1010
00111111	1011
x: Don't care bit	

The output code of the CDS calculation portion 5 is supplied to the DSV calculation portion 4.

The DSV calculation portion 4 supplies the code to the encoder 2 via a latch 6. The end pattern judgement portion 3 supplies the code to the encoder 2 via a latch 7.

Next, the method for selecting a 14-bit digital modulation code corresponding to each inputted 8-bit digital data will be described.

First, the method for selecting up to four 14-bit digital modulation codes for each 8-bit digital data will be described. The 14-bit digital modulation code is selected by the procedures of

(a) selecting among the 2¹⁴ 14-bit digital codes, a digital code the numbers of consecutive identical bits in which are 5 or less in the first 6 bits, 2 - 7 from the second bit to 13th bit, and 6 or less in the last 7 bits, the absolute value of CDS of the selected digital code being 4 or less, and repeating this selecting procedure,

(b) selecting among the selected 14-bit digital codes at the procedure (a), a digital code the first bit of which is "0", and the value of CDS of which is 0, and pairing the selected 14-bit digital code with the reversal code thereof to make the 2 digital codes one group, and repeating this selecting procedure, or selecting among the selected 14-bit digital codes at the procedure (a), a digital code the first bit of which is "1", and the value of CDS of which is +2 or +4, combining the selected 14-bit digital codes with the reversal codes thereof, and further combining the two 14-bit digital codes with a pair of 14-bit digital codes

selected at the above procedure to make the 4 digital codes one group, and repeating this selecting procedure,

- (c) selecting among the selected 14-bit digital codes at the procedure (a), a digital code the first bit of which is "0", and the value of CDS of which is +2, and another digital code the first bit of which is "1", and the value of CDS of which is +2 or +4, and combining the two selected 14-bit digital codes with the reversal codes thereof to make the 4 digital codes one group, and repeating this selecting procedure,
- (d) selecting among the selected 14-bit digital codes at the procedure (a), a digital code the first bit of which is "0", and the value of CDS of which is +4, and another digital code the first bit of which is "1", and the value of CDS of which is +2, and combining the two selected 14-bit digital codes with the reversal codes thereof to make the 4 digital codes one group, and repeating this selecting procedure, and
- (e) selecting 256 groups among the groups formed in the above procedures as the 14-bit digital modulation codes.

Next, the selection procedure of a 14-bit digital modulation code (current modulation code) corresponding to inputted 8-bit data will be described.

First, the DSV at the end of the preceding modulation code is calculated, and the end pattern of the preceding modulation code is decided as one of the twelve end patterns shown in Table 9.

Subsequently, the current 14-bit digital modulation code is selected by the encoder 2 in response to the 8-bit data, the DSV at the end of the preceding modulation code, and the end pattern of the preceding modulation code.

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More specifically, the following steps are taken for selecting the current 14-bit digital modulation code.

- (1) The 14-bit digital modulation codes satisfying the following conditions are selected from Tables 4 and 5: (a) the number of consecutive identical bits at the joint portion with the preceding 14-bit digital modulation code is two to seven; and (b) the absolute value of the DSV at the end of the digital modulation code (called end DSV hereinafter) is equal to or less than two.
- (2) When two or more 14-bit digital modulation codes are selected at step (1), the 14-bit digital modulation code that gives the least absolute value of the end DSV is chosen.
- (3) When two or more 14-bit digital modulation codes are still chosen in step (2), the 14-bit digital modulation code is selected by calculating the bit DSV of the modulation code, determining the bit DSV the absolute value of which is minimum for each modulation code, and choosing the code including the bit DSV whose minimum absolute value is minimum.
- (4) When two or more 14-bit digital modulation codes are further found in step (3), the 14-bit digital modulation code is selected by finding the maximum absolute value of the bit DSV of each modulation code, and choosing the code including the bit DSV whose maximum absolute value is equal to or less than six
- (5) When two or more modulation code are still found in step (4), is selected the 14-bit digital modulation code satisfying the condition that the number of consecutive identical bits at the joint portion with the preceding 14-bit digital modulation code is equal to or less than six.
- (6) When any modulation codes selected at step (4) does not satisfy step (5), or two or more modulation codes satisfy step (5), is selected a 14-bit digital modulation code satisfying the condition that the consecutive identical bits in that modulation code is equal to or less than six.
- (7) When any modulation code selected at step (4) does not satisfy steps (5) and (6), or when any modulation code selected at step (5) does not satisfy step (6), or when two or more modulation codes are further found at step (6), the following steps are taken.
- (7a) When the end DSV of the modulation code is -2, the code of higher priority (corresponding to smaller number in Table 10) is selected according to Table 10. Likewise, when the end DSV of the modulation code is +2, the code of higher priority is selected according to Table 11.
- (7b) When two or more modulation codes belonging to the equal highest priority are found in step (7a), all of them are temporarily selected. When the end DSV is zero, is selected the modulation code satisfying the last six bits of which are not "...111111", nor "...000000" in the modulation codes.
- (8) When any modulation code selected at step (4) does not satisfy steps (5), (6) and (7), or when any modulation code selected at step (5) does not satisfy step (6) and (7), or when any modulation code selected at step (6) does not satisfy step (7), or when two or more modulation codes are further found at step (7), is selected the modulation code including the bit DSV whose maximum absolute value is minimum.
- (9) When two or more modulation codes are still found at step (8), is selected the modulation code including the bit DSV whose minimum absolute value appears fastest in the bit string of the modulation code.
- (10) When two or more modulation codes are further found at step (9), is selected the modulation code whose bit will be reversed fastest after the joint point with the preceding modulation code.

TABLE 10

5	In the case where E the end of modulati is "-2"			
	End pattern of modulation codes	Priority		
	xxxxx001	4		
10	xxxx0011	1		
	xxx00111	2		
	xx001111	3		
15	x0011111	8		
	xxxxx110	10		
	xxxx1100	5		
20	xxx11000	6		
	xx110000	7		
•	x1100000	9		
25	11000000	11		
20	x: Don't care bit			

TABLE 11

In the case where the end of modulat is "+2"	
End pattern of modulation codes	Priority
xxxxx110	4
xxxx1100	1
xxx11000	2
xx110000	3
x1100000	8
xxxxx001	10
xxxx0011	5
xxx00111	6
xx001111	7
x0011111	9
00111111	11
x: Don't care bit	

The 14-bit digital modulation code thus selected is fed to the parallel-to-serial converter 8. The modulation code entered the parallel-to-serial converter 8 is serially read out in synchronism with the clock 9, and is fed to the recording portion 10, where the 14-bit digital modulation code is recorded on the recording medium such as magnetic tape or the like.

On the other hand, the 14-bit digital modulation code selected by the encoder 2 is supplied to the DSV calculation portion 4, and to the end pattern judgement portion 3. The DSV calculation portion 4 adds the CDS of the current modulation code to the DSV at the end of the preceding modulation code to obtain a new DSV. The new DSV is converted into a 2-bit code according to Table 8, and is supplied to the encoder 2 through latch 6. The end pattern judgement portion 3 converts the last 6 bits of the 14-bit modulation code into a 4-bit code according to Table 9, and supplies the 4-bit code to the encoder 2 through latch 7.

The above procedure is repeated for every 8-bit input data. Thus, a 14-bit digital modulation code train is obtained, in which the number of consecutive identical bits is restricted to 2 - 7, and the absolute value of the DSV is restricted equal to or less than 7.

Fig. 2 shows an example of the decoding circuit. In Fig. 2, reference numeral 11 designates a reproducing portion, 12 designates a synchronizing signal detector, 13 denotes a serial-to-parallel converter, and 14 denotes a decoder. The decoding procedure by the decoding circuit will now be described.

The serial modulation code reproduced by the reproducing portion 11 is supplied to the synchronizing signal detector 12 and the serial-to-parallel converter 13. The synchronizing signal detector 12 detects the synchronizing signal inserted at the beginning of the synchronizing block, and supplies it to the parallel-to-serial portion 13. The synchronizing signal is used to synchronize with each 14-bit digital modulation code. The serial-to-parallel converter 13, using the synchronizing signal from the synchronizing signal detector 12, converts the serial 14-bit digital modulation code to a parallel 14-bit digital modulation code, and supplies it to the decoder 14. The decoder 14 decodes the 14-bit digital modulation code into corresponding 8-bit data by using a ROM.

Next, the 14-bit digital modulation code produced from the encoder 2 in Fig. 1 will be described.

The 14-bit digital modulation code converted from the 8-bit code satisfies the following requirements.

- (1) The number of consecutive identical bits in the first 6 bits is equal to or less than 5.
- (2) The number of consecutive identical bits included from the second bit to the 13th bit is 2 7.
- (3) The number of consecutive identical bits included in the last 7 bits is equal to or less than 6.
- (4) The absolute value of CDS of the modulation code is equal to or less than 4.

The end patterns of the modulation codes that satisfy the above requirements (1) to (4) are summed up as the following 12 items (A) - (M).

35	(A)	••• •••	110
	(B)	••• ••• •••	1100
	(C)	••• •••	11000
	(D)	••• •••	110000
40	(E)	••• •••	1100000
	(F)	••• ••• •••	11000000
	(G)	••• •••	001
45	(H)	••• •••	0011
	(J)	••• •••	00111
	(K)	••• •••	001111
50	(L)	••• •••	0011111
50	(M)	••• •••	00111111

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The beginning of the modulation code succeeding to the modulation codes (A) - (M) is one of the following items.

First, the beginning of the modulation code succeeding to the modulation code (A) is one of the following five items (A1) - (A5).

	(A1)	011
	(A2)	0011
5	(A3)	00011
	(A4)	000011
	(A5)	0000011
10		
	Second, the beginning of the modulated following nine items (B1) - (B9).	on code succeeding to the modulation code (B) is one of the
	(B1)	011
15	(B2)	0011
	(B3)	00011
	(B4)	000011
20	(B5)	0000011
	(B6)	1100
	(B7)	11100
25	(B8)	111100
	(B9)	1111100
30	The beginning of the modulation code eight items (C1) - (C8) .	succeeding to the modulation code (C) is one of the following
	(C1)	011
	(C2)	0011
35	(C3)	00011
	(C4)	000011
	(C5)	1100
40	(C6)	11100
	(C7)	111100
	(C8)	1111100
45		
	The beginning of the modulation code seven items (D1) - (D7).	succeeding to the modulation code (D) is one of the following
50	(D1)	011
50	(D2)	0011
	(D3)	00011

(D	4) 1100	• • • • • • • • • • • • • • • • • • • •	• • • •
(D	5) 11100	•••	• • • • • •
(D	6) 111100	•••	• • • • •
. (D	7) 111110	0	• • • • •

The beginning of the modulation code succeeding to the modulation code (E) is one of the following six items (E1) - (E6).

```
(E1) 011 ··· ··· ···
                       (E2) 0011··········
15
                       (E3) 1100··········
                       (E4) 11100 ··· ···
                       (E5) 111100 ··· ···
                       (E6) 1111100
20
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The beginning of the modulation code succeeding to the modulation code (F) is one of the following five items (F1) - (F5).

```
25
                        (F1) 011 ··· ··· ···
                        (F2) 1100···············
                        (F3)
                              11100 ... ...
                        (F4)
                              111100 ... ...
                        (F5) 1111100
```

The beginning of the modulation code succeeding to the modulation code (G) is one of the reversal patterns of the modulation codes (A1) - (A5).

The beginning of the modulation code succeeding to the modulation code (H) is one of the reversal patterns of the modulation codes (B1) - (B9).

The beginning of the modulation code succeeding to the modulation code (J) is one of the reversal patterns of the modulation codes (C1) - (C8).

The beginning of the modulation code succeeding to the modulation code (K) is one of the reversal patterns of the modulation codes (D1) - (D7).

The beginning of the modulation code succeeding to the modulation code (L) is one of the reversal patterns of the modulation codes (E1) - (E6).

The beginning of the modulation code succeeding to the modulation code (M) is one of the reversal patterns of the modulation codes (F1) - (F5).

The numbers of the modulation codes that satisfy the requirements (1) - (4) are shown in Tables 1 and 2. The code "100000001111111" (CDS = 0), and the code "01111111000000" (CDS = 0) are excluded from the numbers.

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TABLE 1

The number of possible modulation codes Beginning pattern of modulation codes **CDS Value** CDS ≤ CDS ≥ Total -4 -2 0000011..... 000011..... 00011..... 0011..... 011..... Total

TABLE 2

Beginning pattern of modulation codes		The number of possible modulation codes								
			CDS	Value				,		
	-4	-2	0	2	4	Total	CDS ≦ 0	CDS ≥		
1111100	0	0	6	8	9	23	6	23		
111100	0	6	10	14	12	42	16	36		
11100	5	11	20	21	15	72	36	56		
1100	11	26	33	29	17	116	70	79		
100	32	47	49	37	17	182	128	103		
Total	48	90	118	109	70	435	256	297		

More than 256 modulation codes whose CDS ≥ 0, and more than 256 modulation codes whose CDS ≤ 0 are necessary, which follow one of the modulation codes (A) - (M). In addition, the converted modulation code must correspond to one 8-bit data to avoid transmission error.

The number of modulation codes that can succeed one of the modulation codes (A) - (M) is shown in Table 3.

For example, the CDS of the modulation codes that terminate with "...00111111" is "2" or "4". Accordingly, the end DSV of the modulation code takes a value of "0" or "2", and so the succeeding modulation code must satisfy the requirements that its CDS \leq 0, and it must begin with any one of the bit train "0000011", "000011", "00011", and "100". The number of the modulation codes that satisfy the requirements are 322 as shown in Table 3, which is greater than the necessary number of 256.

Likewise, the CDS of the modulation codes that terminate with "...11000000" is "-2" or "-4". Accordingly, the end DSV of the modulation code takes a value of "0" or "-2", and so the succeeding modulation code must satisfy the requirements that its CDS ≥ 0, and it must begin with any one of the bit train "1111100", "11100", "11100", "1100", and "011". The number of the modulation codes that satisfy the requirements are 322 as shown in Table 3, which is greater than the necessary number of 256.

TABLE 3

End pattern of modulation codes	Tì	ne numb	ve modu	lation co	des			
	-4	-2	CDS ≦ 0	CDS ≥				
110	70	109	118	90	48	435	297	256
1100	86	152	187	162	101	688	425	450
11000	77	144	181	162	101	665	402	444
110000	65	130	171	156	101	623	366	428
1100000	50	109	151	145	96	551	310	392
11000000	33	80	118	119	85	435	231	322
001	48	90	118	109	70	435	256	297
0011	101	162	187	152	86	688	450	425
00111	101	162	181	144	77	665	444	402
001111	101	156	171	130	65	623	428	366
0011111	96	145	156	109	50	550	392	310
00111111	85	119	118	80	33	435	322	231

Fig. 4 shows the number of modulation codes of respective classes when CDS \ge 0, and Fig. 5 shows the number of modulation code of respective classes when CDS \le 0.

Tables 4 and 5 show the correspondence between the 8-bit data and the modulation codes: Table 4 shows the correspondence when CDS \geq 0; and Table 5 shows the correspondence when CDS \leq 0.

Table 4 (CDS \geq 0)

	Class	8-bit	Modulation codes beginning with "0"	CDS	Class	8-bit data	Modulation codes beginning with "1" CDS	
5		data 0	01111110000001	0		0	10000001111110 0	
		1 2 3	01111100110000	000		1 2 3	10000011001111 0 10000011100111 0 10000011110011 0	.
		3 4 5	01111100000110	0 0		5	10000011111001 0	
10		6 7	01111001110000	000		6 7 · 8	10000110001111 0 10000110011110 0 10000111000111 0	· 1
		8 9 10	01111000111000	00		10	10000111001110 0	
15		11 12	01111000011001	000		11 12 13	10000111100110 0 10000111110001 0 10000111111000 0	
		13 14 15	01111000000111	00		14 15	10001100001111 0	
		16 17	01110011001100	000		16 17 18	10001100110011 0)
20		18 19 20	01110011000011	000		19	10001110000111	}
		21 22	01110001100110	0		21 22 23	10001110011001 0 10001110011100 0 10001111000011 0	
		23 24 25	01110000111100	000		24	10001111000110)
25		26 27	01110000011110	0		26 27)
		28 29 30	01100111110000	000		28 29 30	10011000011110	
30		31 32	01100111000110	0		31 32	10011000111100	
	1 (A)	33 34 35	011001100111001 011001 0110011001	000	1 (B)	33 34 35	10011001100110	0
		36 37	01100110000111	0		36 37	10011100000111	0
35		38	01100011110001			38 39 40	10011100011001	0
		40	01100011001110	0		41	10011100110001	0
40		43	01100001111100	0		43 44 45	10011110000110	
10		45 46 47	01100001110011	0		46		0
		48	01100000011111			48	10011111100000	0 2
45		50 51	01111111000110	4	Ì	50 51 52	10000110011111	2 2 2
		52 53 54	01111110011100	4		53 54	10000111110011	2 2
		55 56	0111111000011	1 4		55 56 57	10000111111100	2 2 2
50		57 58 59	01111100111001	1 4		58 59	10001110001111	222222222222
		60	0111110000111	1 4		60	10001111000111	2 2
55		62 63	0111100111100	1 4		62	10001111100011	2

Table 4 (CDS ≥ 0)

	Class	8-bit data	Modulation codes beginning with "0"	COS	Class	8-bit data	Modulation codes beginning with *1*	CDS
5		64	01111001100111	4		64	10001111110001	2
		.65 66 67	01111000111110	4		65 66 67	100011111111000	2 2 2
10		68 69	01110011111001	4		68 69	10011001100111	2 2
		70 71 72	01110011100111	4		70 71 72	10011001111001	2 2 2
		73 74	01110000111111	4		73 74	10011100011110	2 2
15		75 76 77	01100111111001	٥٠٠		75 76 77	10011100111001 10011100111100 10011110000111	2 2 2
		78 79	01100111001111	4	1 (B)	78 79 80	10011110001110 10011110011001 10011110011100	2 2
20		80 81 82	01100011111110	2 2		81 82	10011111000011	2 2 2 2 2 2 2
		83 84	01111110001100 01111110000110 011111110000011	2 2 2 2		83 84 85	10011111001100	2 2 2
		85 86 87	01111100111000	2 2		86 87	10001111001111	4
25		88 89 90	01111100011100 01111100011001 01111100001110	2 2 2		88 89 90	10001111110011	4.
		91. 92	01111100000111	2 2		91 92 93	10011110001111	4
30		93 94 95	0111100111001	2 2 2		94 95	10011111001110	4
	 	96 97	01111000111100	2 2		96 97 98	110001111100110	\$
	1 (A)	98 99 100	01111000110011 01111000011110 01111000001111	2 2		99 100	11000000111111	2 2
35		101	01110011111000 01110011110001 01110011100110	2 2		101 102 103	11000011001111	2 2 2
		103 104 105	01110011100011	222222222222222222222222222222222222222	l	104 105	11000011111001	2
40		106 107 108	0111001100011100	2 2		106 107 108	11000110001111	2.2 2
40		109	01110001110011	2 2	2 (B)	109 110	11000111001110	2222222
		111 112 113	01110000111110	2 2 2		111 112 113	11000141100110 110001111110001 11000111111000	2 2 2
45		114	01100111110001	2 2		114	11001100001111	
		116	01100111100011	2 2 2		116 117 118	11001100110011 11001100111001 110011001	222222222222
50		119 120	01100110011110	2 2		119 120	11001110000111	2 2 2
50		121 122 123	011000111111001	2		121 122 123	11001110011001 11001110011100 11001111000011	2 2
		124	01100011100111	2 2		124 125	11001111000110	2 2
55		126 127	01100001111110	2]	126 127	110011111100001	2 2

Table 4 (CDS \geq 0)

5	Class	8-bit data	Modulation codes beginning with "0"	CDS	Class	8-bit data	Modulation codes · beginning with "1"	CDS
5		128	00111111100000	0		128	11000000011111	0
		129 130	00111111000001	0		129 130	11000000111110	0
		131	00111110001100	0		131	11000001110011	0
10	1	132 133	00111110000110	0		132 133	11000001111001	0
		134 135	00111100111000	0		134 135	11000011000111 11000011001110	0
		136	00111100011100	0		136	11000011100011	0
		137 138	00111100011001	0		137 138	11000011100110 11000011110001	0
15		139	00111100000111	0		139 140	110000111111000	8
	1	141	00111001110001	0		141	11000110001110	0
		142	00111001100110	00	2 (B)	142 143	11000110011001 11000110011100	0
		144	00111000111100	0		144	11000111000011 11000111000110	0
20	1	146	00111000110011	0		146	11000111001100	0
	1	147	00111000011110	0		147	11000111100001 11000111110000	0
		149	00110011111000	0		149 150	11001100000111	0
	ł	151	00110011110001	0		151	11001100011001	0
25		152 153	00110011100011	8	1	152 153	11001100011100 11001100110001	0
		154	00110011000111	0	1	154 155	11001100111000	00
	1	155 156	00110001111100	0		156	111001110000110	0
		157 158	00110001110011	0		157 158	11001110001100	0
30	Ì	159 160	00110000111110	0		159	11001111000001	0
	2 (A)	161	00111111100001	2		161	11001100111110	4
	2(h)	162 163	00111111001100	2 2		162 163	11001110011110	4
•	1	164	00111111000011	2		165	1110011111001110	4
35	1	166	00111110011001	22222		166	11001111100110	4
		167	00111110001110	2 2		167 168	11100011100111	4
		169	00111100111100	2		169 170	1111000111110011	4
		171	00111100110011	2		171	11100110011110	4
40		172 173	00111100011110	2 2 2	3 (B)	172 173	11100111000111	4
		174	00111001111100	2		174	11100111100011	4.
		176	00111001110011	2 2		176	111001111111000	4 2
45		177	00111001100111	2 2		177 178	11100000011111	
40		179	00111000011111	2		179 180	11100001100111	2 2
		181	00110011111001	2	į	181	11100001111001	2
		182	00110011110011	22222222	ļ	182 183	11100001111100	2
50		184 185	00110011001111	2		184	11100011001110	2 2
		186	00110000111111	2	1	186	11100011100110	2222222222222222
		187	00111111100110	1 4	1	187 188	11100011110001	2
		189	00111111001110	4		189 190	11100110000111	2
55	İ	190	00111110011110			191	11100110011001	2

Table 4 (CDS \geq 0)

	Class	8-bit data	Modulation codes beginning with "0"	CDS	Class	8-bit data	Modulation codes beginning with "1"	COS
5		192 193 194	00111110001111 00111100111110 00111100011111	***		192 193 194	11100110011100 11100111000011 11100111000110	2 2 2 2 2
10	2 (A)	195 196 197 198 199 200	0011100111110 00111000111111 001100111111	444000		195 196 197 198 199 200	11100111001100 11100111100001 11100111111	22000
15		200 201 202 203 204 205 206	00011111000110 0001111100011 000111110011100 00011110011001 00011110001110 00011110000111	0000000	3 (B)	201 202 203 204 205 206 207	11100000111001 11100000111100 11100001100011 11100001100110 11100001110001 11100001111000	0000000
20		208 209 210 211 212 213 214	00011100111001 00011100110011 00011100011110 00011100001111 000110011111001 00011001111001	00000		208 209 210 211 212 213 214	11100011000110 11100011001100 11100011100001 11100011110000 11100110000011 11100110000110	00000
25	3 (A)	215 216 217 218 219	00011001100111 00011000111110 00011000011111 000111111	0 0 0 2 2 2 2		215 216 217 218 219	11100110011000 11100111000001 11100111100000 11110001111100	0 0 0
30		220 221 222 223 224 225 226	00011111100011 00011111001110 00011111001111 00011110011110 00011110011111 000111100111110	2 2 2 2 2 2	4 (B)	220 221 222 223 224 225 226	11110000001111 11110000011110 1111000011001 1111000011100 111100011100	22222222222222222
35		227 228 229 230 231 232 233	00011001111110 000111000111111 000111111	22444444		227 228 229 230 231 232 233	11110001110001 11110001111000 11110011000110 11110011000110 11110011100001 11110011110000	
40	4 (A)	234 235 236 237 238 239 240	0000111111000 0000111110011 000011110011 0000111100111 000011100111	00000		234 235 236 237 238 239 240	11110000000111 1111000001110 1111000011100 1111000011100 1111000111000	000000
45		241 242 243 244 245	00001110001111 00001100111110 00001100011111 0000111111	0 0 0 2	-	241 242 243 244 * 245	11110001110000 11110011000001 11110011100000 11111000000	0 0 2 2
50		246 247 248 249 250	00001111100111	2 2 2	5 (B	246 247 248 249 250	11111000011001 111111000011100 111111000111000 111111	22220
55	5 (A)	251 252	0000011111100 00000111110011 00000111100111 00000111001111	0 0 0		251 252 253 254 255	11111000000110 11111000001100 11111000011000 11111000110000	0 0 0

Table 5 (CDS \leq 0)

		0-1-4	lucation made		 i	8-bit	Modulation codes		
	Class	8-bit data	Modulation codes beginning with "0"	COS	Class	data	beginning with "1"	CDS	
5		0	01111110000001	0		0	10000001111110		
	1 1	ĭ	01111100110000	ŏl	1	ĭ	10000011001111	ŏ	
	1 1		01111100011000	0		2	10000011100111	0	
	}	2 3 4	01111100001100	0	1	3 4 .	10000011110011	ö	
			01111100000011	ŏ	- 1	5 6	100000111111100	0	
10		5	01111001110000	0		6	10000110001111 10000110011110	0	
		7 8	01111001100001	°	1	7 8	10000111000111	ŏ	
		ş	01111000110001	ŏ		9	10000111001110	0	
	'	10	01111000011100	0		10 11	10000111100011	0	
15	Ì	11 12	01111000011001	0		12	10000111110001	0	
13	1	13	01111000000111	0		13	10000111111000	0	
		14	01110011110000	0		14 15	10001100001111	ŏ	
		15	01110011001100	ŏ	i	16	10001100110011	0	
	1	17	01110011000110	0		17 18	10001100111001	0	
20		18	01110011000011	0		19	10001110000111	0	
	}	20	01110001110001	0		20	10001110001110	0	
	1	21 22	01110001100110	8		21 22	10001110011001 10001110011100	ŏ	
		23	01110000111100	.0		23	10001111000011	0	ì
		24	01110000111001	00		24 25	10001111000110	0	
25	1	25 26	01110000110011	ŏ		26	10001111100001	0	
	1	27	01110000001111	0		27	100011111110000	0	
	1	28	01100111110000	0	:	28 29	10011000011110	ŏ	
	1	29 30	01100111001100	ŏ		30	10011000110011	0	
30	1	31	01100111000110	0	į i	31 32	10011000111001	0	
30		32 33	01100111000011	0		33	10011001100011	0	ı
	1 (C)	34	01100110011001	0	1 (D)	34	10011001100110	0	l
	1	35	01100110001110	0	ł	35 36	10011001110001	0	l
		36 37	01100110000111	ŏ		37	10011100000111	0	l
35		38	01100011110001	0	ł	38	10011100001110	0	ĺ
		39 40	01100011100110	0		39	10011100011100	ō	١
	1	41	01100011001110	Ŏ	ł	41	10011100110001	0	l
		42	01100011000111	0		42	1001110011100011	0	١
	1	43	01100001111100	8	ŀ	14	10011110000110	0	l
40		45	01100001110011	0]	45	10011110001100	0	l
		46	01100001100111			46	100111110011000	0	١
	1	47	01100000111110	0	1	48	10011111100000	0	I
	1	49	01111100000001	-2	1	50	10000000110017	-4	I
45		50 51	01111001100000	-2 -2	l	51	10000000111100	-4	ı
40		52	01111000011000	-2		52	10000001100011		١
		53	01111000001100	-2	1	53 54	10000001100110	-4	
		54 55	6011110000000110 6011110000000011	-2 -2	1	55	10000001111000	-4	1
		56	01110011100000	-2		56	10000011000011	-4	١
50		57	01110011000001	-2	1	57 58	10000011000110		1
		58 59	01110001110000	-2	1	59	10000011100001	-4	1
		60	01110000111000	-2		60	10000011110000	-4	
	1	61	01110000110001	-2	1	61	10000110000011	-4	1
		62	01110000011100		1	63	10000110001100	-4	
55	1	63	1 21110000011001	1 -	ı	1		Ī	١

Table 5 (CDS \leq 0)

		0.324	 	_				
5	Class	8-bit data	Modulation codes beginning with "0"	CDS	Class	8-bit data	Modulation codes beginning with "1"	CDS
		64	01110000001110	-2		64	10000110011000	-4
		65 66	01110000000111	-2 -2	,	45 66	10000111000001	-4
		67	01100111000001	-2		67	10001100000011	-4
10		68 69	01100110011000	-2 -2		68 69	10001100000110	-4
10		70	01100110000110	-2	.	70	10001100011000	-4
		71 72	01100110000011	-2 -2		71 72	10001100110000	-6
		73	01100011100001	-2		73	10001111000000	-4
		74 ,	01100011001100	-2		74 75	10011000000011	-:
.15		75 76	01100017000110	-2		76	10011000001100	-4
		77	01100001111000	-2		77 78	10011000011000	-4
	1 (C)	78 79	01100001110001	-2 -2		79	10011000110000	-4
	1 (0)	80	01100001100011	-2		80	10011100000001	-4
20		81 82	01100000111100	-2 -2		81 82	10000000111110	-2
20		83	01100000110011	-2		83	10000001110011	-2
		84 85	01100000011110	-2 -2		84	10000001111001	-2 -2
		86	01110000110000	-4		86	10000011000111	-2
		87	01110000011000	-4 -4		87 88	10000011001110 10000011100011	-2 -2
25		88 89	01110000001100	-4		89	10000011100110	-2
		90	01100011000001	-4		90	10000011110001	-2 -2
		91 92	01100001110000	-4	i	92	10000110000111	-2
		93	01100000111000	-4		93 94	10000110001110	-2 -2
30		94 95	01100000110001	-4		95	10000110011100	-2
30		96	01100000011001	-4	!	96 97	10000111000011	-2 -2
		97 98	00111000011000	-4	1(D)	98	10000111001100	-2
		99	00111111000000	-2		99	10000111100001	-2
	1	100	00111110000001	-2 -2		100	10000111110000	-2 -2
35	1	102	00111100011000	-2		102	10001100001110	-2
		103	00111100001100	-2 -2		103	10001100011001	-2 -2
	1	104	00111100000110	-2		105	10001100110001	-2
		106	00111001110000	-2		106	10001100111000	-2 -2
40		107	00111001100001	-2 -2		108	10001110000110	-2
40		109	00111000110001	-2		109	10001110001100	-2
	2/01	1110	00111000011100	-2 -2		1110	10001110011000	-2 -2
	2 (C)	112	00111000001110	-2		112	10001111100000	-2
	1	113	00111000000111	-2 -2	İ	113	10011000000111	-2 -2
45	1	115	00110011100001	-2	t	115	10011000011001	-2
	1	116	00110011001100	-2 -2	l	116	10011000011100	- 2 -2
		118	00110011000011	-2	i	118	10011000111000	-2
		119	00110001111000	-2	1	119	10011001100001	-2 -2
50		120 121	00110001110001	-2 -2	1	121	10011100000011	-2
		122	00110001100011	-2	I	122	10011100000110	-2
		123 124	00110000111100	-2 -2	1	123 124	10011100001100	-2 -2
	}	125	00110000111001	-2		125	10011100110000	-2
		126	00110000011110	-2	I	126	10011110000001	-2
55		127	00110000001111	-2	<u></u>	127	10011111000000	-2

Table 5 (CDS \leq 0)

	Class	8-bit data	Modulation codes beginning with "0"	CDS	Class	8-bit data	Modulation codes beginning with "1"	CDS
5		128 129 130	00111111100000	000		128 129 130	11000000011111 11000000111110 11000001100111	0 0 0
10		131 132 133 134 135 136	00111110001100 00111110000110 001111100111000 00111100110001 0011110011001	000000		131 132 133 134 135 136	11000001110011 11000001111001 11000001111100 11000011000111 11000011000111 11000011100011	000000
15	2 (C)	137 138 139 140 141 142	00111100011001 00111100001110 001111001111000 00111001110001 00111001100110	00000		138 139 140 141 142 143	11000011110001 11000011111000 11000110000111 11000110001100 11000110011001 110001110011100	000000
20		144 145 146 147 148 149 150	0011100011100 00111000111001 0011100011101 00111000001111 001110011111000 00110011111000	0000000	•	145 146 147 148 149 150	11000111000110 11000111001100 11000111100001 11000111110000 110011000001110 11001100001110	000000
25		151 152 153 154 155 156	00110011100110 00110011100011 001100110	0000000		152 153 154 155 156 157	11001100011100 11001100110001 110011001	0 0 0 0
30		158 159 160 161 162 163	00110001100111 00110000111110 00110000011111 00110011000001 00110001100001 00110000111000	0 0 -4 -4 -4	2 (D)	158 159 160 161 162 163 164	11001110011000 11001111100000 110001111100000 11000000	0 0 0 -2 -2 -2 -2 -2
35		164 165 166 167 168	00110000110001 0011000001100 0011000001001	-6 -6 -4		165 166 167 168	11000001100011 11000001100110 11000001110001 11000001111000	-2 -2 -2 -2
40	3 (C)	169 170 171 172 173 174 175	00011100001100 00011100000011 000110001100001 00011000110001 00011000011100 00011000011100 000110000111001	-4-4-4		169 170 171 172 173 174 175	11000011000011 11000011000110 1100001100101 11000011100001 11000110000011 11000110000110	-2 -2 -2 -2 -2 -2 -2 -2 -2 -2 -2 -2 -2 -
45		177 178 179 180 181 182	0001111100000 0001111000001 0001111001100 0001111000110 00011110000110	-2 -2 -2 -2 -2		177 178 179 180 181 182	11000110011000 11000111000001 11000111100000 110011000000	-2 -2 -2 -2 -2 -2 -2 -2 -2 -2 -2 -2 -2 -
50		183 184 185 186 187 188 189	00011100111000 00011100110001 00011100011000 00011100011001 0001100000111 00011001111000	-2 -2 -2 -2 -2 -2		183 184 185 186 187 188 189	11001100011000 11001100110000 1100111000000	22224444
55		190	00011001110001			191	11000001100001	-4

Table 5 (CDS \leq 0)

	_		· · · · · · · · · · · · · · · · · · ·					
	Class	8-bit	Modulation codes	CDS	Class	8-bit	Modulation codes	CDS
_		data	beginning with "O"			data	beginning with "1"	<u> </u>
5		192	00011001100011	-2		192	11000001110000	-4
		193	00011000111100	-2		193	11000011000001	-4
	1	194	00011000111001	-2		194	11000011100000	-4
	1 1	195	00011000110011	-2	1	195	11000110000001	-4
	1	196	00011000011110	-2	2 (D)	196	11000111000000	-4
		197	00011000001111	-2	8 (8)	197	11001100000001	-4
10		198	00011111110000	0	ì	198	11100000001111	0
		199	00011111100001	0		199	11100000011110	0
		200	00011111001100	0		200	11100000110011	0
	3(C)	201	00011111000110	0		201	11100000111001	0
	3(0)	202	00011111000011	0		202	11100000111100	0
		203	00011110011100	0	: 1	203	11100001100011	0
15		204 205	00011110011001	0		204 205	11100001100110 11100001110001	0
		206	00011110000111	ŏ		206	11100001111000	00
		207	00011100111100	ŏ		207	11100011000011	ŏ
	1 1	208	00011100111001	ŏ		208	11100011000110	ŏ
		209	00011100110011	ŏ		209	11100011001100	ŏ
	l i	210	00011100011110	0		210	11100011100001	Ŏ
20	.	211	00011100001111	0		211	11100011110000	0
		212	00011001111100	0		212	11100110000011	0
	, 1	213	00011001111001	0		213	11100110000110	0
		214	00011001110011	0		214	11100110001100	0
		215	00011001100111	0	3(D)	215	11100110011000	0
	i i	216 217	00011000111110	0		216 217	11100111000001 11100111100000	8
25	-	218	00001110000011			218	11100000001110	-2.
		219	00001100000111	-4		219	11100000011001	-2
		220	00001111110000	-ž		220	11100000011100	-2
		221	00001111100001	-2		221	11100000110001	-2
		222	00001111001100	-2		222	11100000111000	-2
		223	00001111000110	-2		223	11100001100001	-2
30		224	00001111000011	-2		224	11100001110000	-2
		225	00001110011100	-2		225	11100011000001	-2
	4 (C)	226	00001310011001	-2		226	11100011100000	-2
		227	00001110001110	-2		227	11100110000001	-2.
		228	00001110000111	-2 .		228	11100111000000	-2
		229	00001100111100	-2		229 230	11100000001100	-4
35		230 231	00001100111001 00001100110011	-2 -2		231	11100000011000	-4
		232	00001100011110	-2		232	11100001100000	-4
		233	00001100001111	-2		233	11100011000000	-4
		234	00001111111000	õ		234	11110000000111	-
		235	00001111110001	Ŏ		235	11110000001110	ŏ
		236	00001111100110	0		236	11110000011001	Ŏ
40		237	00001111100011	0		237	11110000011100	Ō
l		238	00001111001110	0		238	11110000110001	0
l	{	239	00001111000111	0		239	11110000111000	0
ļ		240	00001110011110	0.		240	11110001100001	0
	ı	241	00001110001111	0	4/5	241	11110001110000	0
ļ		242	00001100111110	0	4 (D)	242	11110011000001	١١
45		243	00001100011111	0	1	243	11110011100000	0
	- 1	244	00000111111000	-2		244	111110000000110	-2
	ł	245	00000111110001	-2		245	11110000001100	-2
	ļ	246	00000111100110	-2	1	246	11110000011000	-2
ļ	l	247	00000111100011	-2	! !	247 248	11110000110000	-2
}	Ì	248	00000111000111	-2	i l	248 249	11110011000000	-2 -2
50	5(C)	249 250	00000110001111	-2 0		250	11111000000011	
	3(0)	251	00000111111001	ö	1	251	11111000000110	ő
	1	252	00000111110011	ŏ		252	11111000001100	0
	İ	253	00000111100111	ő	5 (D)	253	11111000011000	ŏ
	i	254	00000111001111	ŏ	"	254	11111000110000	ŏ
	1	255	00000110011111	ŏ		255	11111001100000	ŏ
55					L			

The modulation codes in 5(B) of Table 4 can be changed as shown in Table 12 to improve the end DSV: the six modulation codes whose CDS = 0 in 5(B) is reduced to four by two, and two new modulation codes which have not been used and whose CDS = 2 are added.

TABLE 12

8-bit data	Modulation codes	CDS
248	11111000110001	2
249	11111000111000	2
250	11111001100001	2
251	11111001110000	2

Selecting a modulation code whose CDS = 2 makes it possible to adjust the end DSV at the end of the selected modulation code to 0, when the end DSV at the end of the preceding modulation code is -2, the last bit pattern of the preceding code is any one of the patterns "01", "100", "1000", "10000", "100000", and "1000000", and the signal data is 250 or 251. The modulation codes in 5(C) of Table 5, which are the reversal codes of those in 5(B) of Table 4, can also be changed as shown in Table 13.

TABLE 13

8-bit data	Modulation codes	CDS
248	00000111001110	-2
249	00000111000111	-2
250	00000110011110	-2
251	00000110001111	-2

Modulation codes which are not used in Tables 4 and 12, and whose CDS = 4 can be used in place of the modulation codes in Table 4 or in Tables 4 and 12. Selecting a modulation code whose CDS = 4 when the end DSV at the end of the preceding modulation code is -2 can improve the bit DSV of the selected modulation code because the bit DSV is sure to take 0 at a particular bit in the selected modulation code.

The modulation codes in Table 5 and Table 13, which are reversal patterns of the codes in Table 4 and Table 12, can be changed in a manner similar to the above, resulting in a similar improvement.

The modulation codes specified to correspond to 8-bit data in Tables 4 and 5 are an example, and so the combination of the modulation codes and the 8-bit code can be altered.

Types of the modulation codes that are allowed to take place according to the end pattern of the preceding modulation code are shown in Table 6.

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TABLE 6

i												 ,
5			of	nsecu "0" begi odula	bits nning	at tl	he	of	nsecu "1" begi nodula	bits nning	at t	he
10		CDS <u>≥</u> 0 ′	1 (A)	2 (A)	3 (A)	4 (A)	5 (A)	1 (B)	2 (B)	3 (B)	4 (B)	5 (B)
	S	CDS <u>≤</u> 0 -	1 (C)	2 (C)	3 (C)	4 (C)	5 (C)	1 (D)	2 (D)	3 (D)	4 (D)	5 (D)
15	codes	110	0	0	0	0	0					
20	modulation	1100	0	0	0	0	0		0	0	0	0
	dula	11000	0	٥	0	0			0	0	0	0
25		110000	0	٥	0				0	0	0	0
	preceding	1100000	0	0					0	0	0	0
30		11000000*	0						0	٥	0	0
	the	001							0	0	0	٥
35	n of	0011		٥	0	٥	٥	0	٥	0	0	o
	pattern	00111		0	0	٥	٥	0	٥	0	٥	
40	End pa	001111		0	0	٥	0	0	0	0		
	Ē	0011111		0	0	0	0	0	0			
45		00111111*		0	0	0	0	0				

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Notes with regard to Table 6:

For example, when the end pattern of the preceding modulation code is "...11000", and the end DSV of

[&]quot;o" mark indicates that the modulation codes are allowed.

[&]quot;" indicates that a modulation code whose CDS ≥ 0 is selected when the end pattern of the preceding modulation code is "...11000000", and that a modulation code whose CDS ≤ 0 is selected when the end pattern of the preceding modulation code is "...00111111".

the preceding modulation code is -2, the modulation codes of classes 1(A), 2(A), 3(A), 4(A), 2(B), 3(B), 4(B), and 5(B) in Table 4 can take place as a current modulation code because the current modulation code to be selected must satisfy the requirements that the CDS ≥ 0 and the number of consecutive identical bits in the joint portion of the two codes is 2 - 7.

In this case, suppose that the current 8-bit data is "166". Then, one of the two possible modulation codes "00111110011001" (CDS = 2; 2(A)), and "11001111100110" (CDS = 4; 2(B)) shown in Table 4 is selected: the end DSV of the preceding modulation code and the CDS of the current modulation code are added so as to obtain the end DSV of the current modulation code; the modulation code which will give less end DSV is selected, that is, the modulation code "00111110011001" (CDS = 2) is selected. The resultant end DSV is 0 and it indicates that the direct current component is removed.

Fig. 3A shows the CNR (carrier-to-noise ratio) characteristics when a sine wave recorded on magnetic tape is reproduced, Fig. 3B shows the power spectrum at the output terminal of the modulator of the embodiment when random 8-bit data are inputted to the modulator, and Fig. 3C shows the power spectrum of the scrambled NRZ at the output terminal of the scrambled NRZ modulator when random 8-bit data are inputted to the scrambled NRZ modulator. From these figures, it is seen that the power spectrum according to the digital modulation method of the present invention includes no direct current component, and is included within a record-reproduction bandwidth in which the high CNR is obtained. As a result, the record-reproduction characteristics of the magnetic tape and head system can be effectively used. Furthermore, the minimum magnetization transition width of the modulation codes of the digital modulation method according to the present invention is 1.14 times the minimum magnetization transition width of the scrambled NRZ. Consequently, the intercode interference can be reduced.

As described above, the embodiment restricts the number of consecutive identical bits in a stream of modulation codes to 2 - 7. As a result, the minimum magnetization transition width is 1.14T (= (28)T/14, where T is the bit period of the 8-bit data), the maximum magnetization transition width is 4.00T (= $(7 \times 8)-T/14$), DR is 1.14 (= $(2 \times 8)/14$), and the ratio of the maximum magnetization transition width to the minimum magnetization transition width is 3.5. Consequently, the bit error rate of the magnetic recording is reduced, and the high-density recording becomes possible. In addition, azimuth recording and high quality over-writing become possible.

Furthermore, the embodiment restricts the absolute value of CDS of the modulation codes equal to or less than 4, allocates up to 4 modulation codes to each 8-bit data according to the DSV at the end of the preceding modulation code and the end pattern of the preceding code, and selects the modulation code the end DSV of which gives the least absolute value. As a result, the absolute value of the end DSV which is calculated at the end of each modulation code is within 2, and the absolute value of the bit DSV which is calculated at each bit of a modulation code is within 7. Thus, the direct current component can be effectively removed, and hence, the transmission of the modulation codes becomes possible by using a rotary transformer that does not pass the direct current component.

(B) SECOND EMBODIMENT

Fig. 6 is a block diagram showing a digital modulation apparatus for carrying out the digital modulation according to the second embodiment of the digital modulation method of the present invention.

In Fig. 6, 8-bit digital data 1 is converted to a 14-bit digital modulation code by an encoder 2. An end pattern judgement portion 3 converts the end pattern of the last 5-bits of the 14-bit digital modulation code into a 4-bit code in Table 21 (although the last 7 bits of the modulation codes are given in Table 21, only the last 5 bits should be considered). A CDS calculation portion 5 computes the CDS of the 14-bit digital modulation code supplied, and converts the resultant CDS into a 3-bit code in Table 20. A DSV calculation portion 4 adds the CDS of the current 14-bit digital modulation code to the DSV at the end of the preceding 14-bit digital modulation code, yielding a new DSV, and converts the new DSV into a 3-bit code shown in Table 20.

A parallel-to-serial converter 8 converts the 14-bit digital modulation code into a serial signal in synchronism with a clock signal 9. A recording portion 10 records the serial modulation signal produced from the parallel-to-serial converter 8 on a recording medium such as magnetic tape or the like.

TABLE 20

CDS, DSV of Corresponding modulation codes 3-bit codes 000 -6 -4 001 -2 010 0 011 2 100 101 6 110

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TABLE 21

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End pattern of the preceding modulation codes	Corresponding 4-bit codes
xxxx110	0000
xxx1100	0001
xx11000	0010
x110000	0011
1100000	0100
xxxx001	1000
xxx0011	1001
xx00111	1010
x001111	1011
0011111	1100
x: Don't care bit	

The resultant CDS converted into a 3-bit code shown in Table 20 by the CDS calculation portion 5, is supplied to the DSV calculation portion 4.

The DSV calculation portion 4 converts the resultant DSV into a 3-bit code shown in Table 20, and supplies the code to the encoder 2 via a latch 6. The end pattern judgement portion 3 converts the last five bits into a 4-bit code in Table 21, and supplies the code to the encoder 2 via a latch 7.

Next, the method for selecting a 14-bit digital modulation code corresponding to each inputted 8-bit digital data will be described.

First, the method for selecting up to four 14-bit digital modulation codes for each 8-bit digital data will be described.

The 14-bit digital modulation code is selected by the procedures of

- (a) selecting among the 2¹⁴ 14-bit digital codes, a digital code the numbers of consecutive identical bits in which are 6 or less in the first 7 bits, 2 7 from the second bit to 13th bit, and 5 or less in the last 6 bits, and repeating this selecting procedure,
 - (b) selecting among the 14-bit digital codes selected at the procedure (a), a digital code the first bit of which is "0", and the CDS of which has the absolute value equal to or less than 6, and repeating this

selecting procedure,

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- (c) selecting among the 14-bit digital codes selected at the procedure (a), a digital code the first bit of which is "1", and the CDS of which has the absolute value equal to or less than 4, and repeating this selecting procedure,
- (d) selecting among the 14-bit digital codes selected at the procedure (b), a digital code the value of CDS of which is 0, and pairing the selected 14-bit digital code with the reversal code thereof to make the 2 digital codes one group, and repeating this selecting procedure,
- (e) selecting among the 14-bit digital codes selected at the procedure (b), a digital code the value of CDS of which is +2, +4 or +6, selecting among the 14-bit digital codes selected at the procedure (c), a digital code the value of CDS of which is +2 or +4, and combining the two selected 14-bit digital codes with the reversal codes thereof to make the 4 digital codes one group, and repeating this selecting procedure, and
 - (f) selecting 256 groups among the groups formed in the above procedures as the 14-bit digital modulation codes.

Next, the selection procedure of a 14-bit digital modulation code (current modulation code) corresponding to inputted 8-bit data will be described with reference to Fig. 7, which is a flowchart showing the modulation procedure according to the digital modulation method of the present invention.

At step S1, DSV at the end of the preceding modulation code is calculated.

At step S2, the end pattern of the preceding modulation code is judged.

At step S3, when the DSV < 0, the modulation codes in Table 17 are selected, and when DSV > 0, the modulation codes in Table 18 are selected. On the other hand, when DSV = 0 and the end pattern of the preceding code is any one of "...110", "...0011", "...00111", "...001111", and "...0011111", the modulation codes in Table 18 are selected. Further, when DSV = 0 and the end pattern of the preceding code is any one of "...11000", "...110000", "...1100000", and "...001", the modulation codes in Table 17 are selected.

At step S4, a modulation code is selected among the selected codes at step S3 and among the classes 1(A) - 6(D) in Tables 17 and 18, according to the end pattern of the preceding modulation code.

At step S5, is selected a modulation code which gives DSV the absolute value of which is minimum when two or more modulation codes are selected at step S4. In this case, the DSV is obtained by adding the DSV at the end of the preceding modulation code and the CDS of the current modulation code.

At step S6, a modulation code that satisfies the following requirements is selected when two or more modulation codes selected at step S5 have the same minimum DSV.

When DSV < 0 at the end of the preceding modulation code, a modulation code whose first bit is "1" is selected.

When DSV > 0 at the end of the preceding modulation code, a modulation code whose first bit is "0" is selected.

When DSV = 0 at the end of the preceding modulation code, a modulation code whose first bit is opposite to the last bit of the preceding modulation code.

The 14-bit digital modulation code thus selected is fed to the parallel-to-serial converter 8. The modulation code entered the parallel-to-serial converter 8 is serially read out in synchronism with the clock 9, and is fed to the recording portion 10, where the 14-bit digital modulation code is recorded on the record medium such as magnetic tape or the like.

On the other hand, the 14-bit digital modulation code selected by the encoder 2 is supplied to the DSV calculation portion 4, and to the modulation code end pattern judgement portion 3. The DSV calculation portion 4 adds the CDS of the current modulation code to the DSV at the end of the preceding modulation code to obtain a new DSV. The new DSV is converted into a 3-bit code according to Table 20, and is supplied to the encoder 2 through latch 6. The end pattern judgement portion 3 converts the last 5 bits of the 14-bit modulation code into a 4-bit code according to Table 21, and supplies the 4-bit code to the encoder 2 through latch 7.

The above procedure is repeated for every 8-bit input data. Thus, a 14-bit digital modulation code train is obtained, in which the number of consecutive identical bits is restricted to 2 - 7, and the absolute value of the DSV is restricted equal to or less than 8.

Next, the 14-bit digital modulation code produced from the encoder 2 in Fig. 6 will be described.

The 14-bit digital modulation code converted from the 8-bit code satisfies the following requirements.

- (1) The number of consecutive identical bits in the first 7 bits is equal to or less than 6.
- (2) The number of consecutive identical bits included from the second bit to the 13th bit is 2 7.
- (3) The number of consecutive identical bits included in the last 6 bits is equal to or less than 5.
- (4) The absolute value of CDS of the modulation code is equal to or less than 6.

The end patterns of the modulation codes that satisfy the above requirements (1) to (4) are summed up as the following 10 items (A) - (K).

5	(A)	110
3	(B)	··· ··· 1100
	(C)	··· ··· 11000
	(D)	··· ··· 110000
10	(E)	··· ··· 1100000
	(F)	········ 001
	(G)	········ 0011
15	(H)	···· ··· 00111
	(J)	··· ··· 001111
	(K)	··· ··· 0011111

The beginning of the modulation code succeeding to the modulation codes (A) - (K) is one of the following items.

First, the beginning of the modulation code succeeding to the modulation code (A) is one of the following five items (A1) - (A6).

(A6)

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Second, the beginning of the modulation code succeeding to the modulation code (B) is one of the following ten items (B1) - (B10).

00000011

```
(B1)
                                011 ... ... ...
                        (B2)
                                0011... ... ...
45
                        (B3)
                                00011 ......
                                000011 ... ...
                        (B4)
                                0000011 ......
                        (B5)
50
                        (B6)
                                1100... ... ...
                        (B7)
                                11100 ... ...
                        (B8)
                                111100 ... ...
                        (B9)
                                1111100 ......
55
                                11111100 ... ...
                        (B10)
```

The beginning of the modulation code succeeding to the modulation code (C) is one of the following nine items (C1) - (C9).

5	(C1)	011
	(C2)	0011
	(C3)	00011
	(C4)	000011
10	(C5)	1100
	(C6)	11100
	(C7)	111100
15	(C8)	1111100
	(C9)	11111100

The beginning of the modulation code succeeding to the modulation code (D) is one of the following eight items (D1) - (D8).

```
(D1)
                               011 ... ... ...
                                0011... ... ...
                        (D2)
25
                        (D3)
                               00011 ......
                               1100 ... ... ...
                        (D4)
                        (D5)
                               11100 ......
30
                        (D6)
                               111100 ... ...
                        (D7)
                               1111100
                        (D8)
                               11111100 ... ...
```

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The beginning of the modulation code succeeding to the modulation code (E) is one of the following seven items (E1) - (E7).

```
011 ... ... ...
40
                        (E1)
                        (E2)
                                0011... ... ...
                        (E3)
                                1100... ... ...
                        (E4)
                                11100 ... ...
45
                        (E5)
                                111100 ... ...
                        (E6)
                                1111100
                        (E7)
                                11111100 ... ...
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```

The beginning of the modulation code succeeding to the modulation code (F) is one of the reversal patterns of the modulation codes (A1) - (A6).

The beginning of the modulation code succeeding to the modulation code (G) is one of the reversal patterns of the modulation codes (B1) - (B10).

The beginning of the modulation code succeeding to the modulation code (H) is one of the reversal patterns of the modulation codes (C1) - (C9).

The beginning of the modulation code succeeding to the modulation code (J) is one of the reversal

patterns of the modulation codes (D1) - (D8).

The beginning of the modulation code succeeding to the modulation code (K) is one of the reversal patterns of the modulation codes (E1) - (E7).

The numbers of the modulation codes that satisfy the requirements (1) - (4) are shown in Tables 14 and

TABLE 14

Beginning pattern of modulation codes			The	number	of pos	sible n	nodulai	ion code	es •	
	-6	-4	-2	0	2	4	6	Total	CDS ≤ 0	CDS 2
00000011	5	6	5	1	0	0	0	17	17	1
0000011	6	9	8	6	0	0	0	29	29	6
000011	6	12	14	10	5	0	0	47	42	15
00011	7	14	21	20	10	4	0	76	62	34
0011	5	17	28	33	25	10	3	121	83	71
011	4	15	37	49	46	31	8	190	105	134
Total	33	73	113	119	86	45	11	480	338	261

TABLE 15

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Beginning pattern of modulation codes			The	numbe	r of pos	sible n	nodulat	ion code	s	•
	-6	-4	-2	0	2	4	6	Total	CDS ≤ 0	CDS ≥ 0
11111100	0	0	0	1	5	6	5	17	1	17
1111100	0	0	. 0	6	8	9	6	29	6	29
111100	0	0	5	10	14	12	6	47	15	42
11100	0	4	10	20	21	14	7	76	34	62
1100	3	10	25	33	28	17	5	121	71	83
100	8	31	46	49	37	15	4	190	134	105
Total	11	45	86	119	113	73	33	480	261	338

More than 256 modulation codes whose CDS \geq 0, and more than 256 modulation codes whose CDS \leq 0 are necessary, which follow one of the modulation codes (A) - (K). In addition, the converted modulation code must correspond to one 8-bit data to avoid transmission error.

The number of modulation codes that can succeed one of the modulation codes (A) - (K) is shown in Table 16.

TABLE 16

5	End pattern of modulation codes	The number of possible successive modulation codes									
			CDS Value								
		-6	-4	-2	0	2	4	6	Total	CDS ≤ 0	CDS ≥ 0
10	110	33	73	113	119	86	45	11	480	338	261
	1100	31	81	148	188	162	103	40	753	448	493
	11000	25	72	140	182	162	103	40	724	419	487
15	110000	19	60	126	172	157	103	40	677	377	472
	1100000	12	46	105	152	147	99	40	601	315	438
	001	11	45	86	119	113	73	33	480	261	338
	0011	40	103	162	188	148	81	31	753	493	448
20	00111	40	103	162	182	140	72	25	724	487	419
	001111	40	103	157	172	126	60	19	677	472	377
	0011111	40	99	147	157	105	46	12	601	438	315

Fig. 8 shows the number of modulation codes of respective classes when CDS \geq 0, and Fig. 9 shows the number of modulation code of respective classes when CDS \leq 0.

Tables 17 and 18 show the correspondence between the 8-bit data and the modulation codes: Table 17 shows the correspondence when CDS \ge 0; and Table 18 shows the correspondence when CDS \le 0.

Table 17 (CDS \geq 0)

5		8-bit	Modulation codes			8-bit	Modulation codes	
	Class	data	beginning with "0"	CDS	Class	data	beginning with "1"	CDS
10		0 1 2 3 4 5	0111110000001 01111100110000 01111100011000 01111100001100 01111100000110 01f11100000011	0000000	•	0 1 2 3 4 5	10000001111110 1000001100111 1000001110011 1000001111001 1000001111100 10000110001111	0 0 0 0 0 0 0 0
15		7 8 9 10 11	0111100110001 011110001110001 01111000110001 01111000011100 01111000011101	000000		7 8 9 10 11 12	10000110011110 10000111000111 10000111001110 10000111100011 1000011110001	0 0 0
20		13 14 15 16 17 18 19 20 21	01110000000111 011100111100001 01110011000100 01110011000110 01110011000011 01110001110001 01110001100011	0000000		14 15 16 17 18 19 20	10001100001111 10001100011110 10001100110011 1000110011100 1000110000111 10001110001110 100011100011001	0000000
25	1 (A)	22 23 24 25 26 27	01110001100011 01110000111100 01110000110011 0111000011011	00000	1 (B)	22- 23 24 25 26 27 28	10001110011100 10001111000011 10001111000110 1000111110000 1000111110000 10011000001111	000000
30		28 29 30 31 32 33	0110011100001 01100111001100 01100111000110 01100111000011 01100110011100	000000		29 30 31 32 33 34	10011000011110 10011000110011 10011000111100 10011000111100 10011001100011	0 0 0 0
35		35 36 37 38 39 40 41	01100110001110 01100011110001 01100011110001 01100011100011 01100011100011	000000		35 36 37 38 39 40 41	1001100111000 10011100000111 10011100001110 10011100011001 1001110011100	0 0 0 0 0 0
40		42 43 44 45 46 47 48 49	01100011000111 0110000111100 01100001110011 01100001100111 01100000111110 011011	0 0 0 0 0 2 2		42 43 44 45 46 47 48 49	1001110011100001 10011110000110 10011110001100 10011110011000 10011111000001 100111111	0 0 0 0 0 2 2
45		51 52 53 54 55	0111110001100 01111110000110 0111111001110 01111100111001 01111100111001	2 2 2 2 2		51 52 53 54 55 56	1000011100111 1000011110011 1000011111001 10000111111	2 2 2 2 2 2 2 2
50		56 57 58 59 60 61 62 63 64	0111100011001 01111100001110 01111100000111 01111001111000 01111001110001 01111001100011 01111000111100	2 2 2 2 2 2 2 2 2		57 58 59 60 61 62 63 64 65	10001100111110 10001110001111 10001111000111 10001111000111 10001111001110 10001111100110 1000111111	2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
55		66	0111100011001			66	10011000011111	2

Table 17 (CDS \geq 0)

•								
5	1 1	8-bit	Modulation codes			8-bit	Modulation codes	
	Class	data	beginning	CDS	Class	data	beginning	CDS
	-		with "0"				with "1"	
					•	67	10011000111110	2
		67 68	01111000011110	2 2		68	10011001100111	2
10		69	01110011111000	2		69	10011001110011	2
		70	01110011110001	2		70	10011001111001	2
		71	01110011100110	2		71 72	10011001111100	2
	1	72	01110011100011	2 2		73	10011100011110	2
		73	01110011000111] 2		74	10011100110011	2
	1	75	01110001111100	2	ŀ	75	10011100111001	2
15		76	01110001111001	2	1 (B)	76 77	10011100111100	2
	1	77	01110001110011	2 2	* (0)	78	10011110001110	2
	1	78	01110000111110	2		79	10011110011001	2
	1	80	01110000011111	2	•	80	10011110011100	2
	1	81	01100111111000	2	1	81	10011111000011	2
	1	82	01100111110001	2 2	i	83	10011111001100] 2
20	1	83	01100111100011	1 2		14	100111111100001	2
		85	01100111001110	2	ł	8.5	100111111110000	2
	1 (A)	86	01100111000111	2		86	10011111000111	4
	1	87	01100110011110	2 2	ì	1 11	11000110011111	1 4 1
		88	01100110001111	1 2		89	11000111001111	4
25		90	01100011111001	2	1	90	11000111100111	1 4 1
25	i	91	01100011110011	2	1	91	11000111110011	
	1	92	01100011100111	2 2	1	93	11000111111100	1 4 1
	1	93	01100001111110	1 2		94	11001100011111	141
	1	95	01111111001100	4	Į.	95	11001100111110	1 !
	1	98	01111111000110	1 4	l .	96	11001110001111	4
30		97	01111111000011	1 4		98	11001111000111	11
		98	d1111110011001	14	1	99	11001111001110	4
	1	100	01111110001110	4	1	100	11001111100011	1 4 1
	1	101	01111110000111	14	ł	101	11000001111110	2
	1	102	01111100111100	12	1	103	11000011100111	2
	1	104	01111100110011	14	1	104	11000011110011	2
35	1	105	01111100011110	1 4	1	105	11000011111001	2
	}	106	01111100001111	1 4	2 (8)	106	11000011111100	1 2 1
	l l	107	01111001111100	14		108	11000110011110	1 2
	i i	109	01111001110011	4	·1·	109	11000111000111	2
	ļ	110	01111001100111	1 4	1	110	11000111001110	2 2
40	1	1111	01111000111110		l .	1111	11000111100110	2
40	- 1	112	01110011111100		1	113	11000111110001	2
	1	1114	01110011111001	. 4		114	110001111111000	2
	1	115	01110011110011		Į.	115	11001100001111	2
		116	01110011100111			117	11001100110011	2
	1	117			1	118	11001100111001	2
45	1	119	01100111111100	1		119	11001100111100	
		120	0110011111100			120	11001110000111	
	1	121			1	122	11001110011001	
	1	122				123	11001110011100	2
		124	0110011001111	1 4	I	124	11001111000011	
		125	0110001111111		1	125	11001111000110	
50	- 1	126			1	127	11001111100001	1 - 1
	1	127		-	1	128	11001111110000	2
	1	125			7	129	11000000011111	
		130	0011111100000	1 0	i	130	110000001111110	
	2 (A)	131			1	131	1100000110011	
EE		133			1	133	11000001111001	
55	l l	1 ,,,	-	٠, ٧	3	1	1	' '

Table 17 (CDS \geq 0)

_			iabie		(000	,		
5	Class	8-bit data	Modulation codes beginning with "O"	CDS	Class	8-bit data	Modulation codes beginning with "1"	CDS
10		134 135 136 137 138 139	00111110000011 00111100111000 001111001110001 00111100011100 00111100001110 00111100001110	000000	-	134 135 136 137 138 139	11000001111100 11000011000111 11000011001110 11000011100011 11000011100011 11000011110001	000000
15		141 142 143 144 145	00111001111000 00111001110001 00111001100110 00111001100011 00141000111100	000000	a /n\	141 142 143 144 146	11000110000111 11000110001110 11000110011100 110001100011100 11000111000011	000000
20		147 148 149 150 151 152 153	00111000110011 00111000011110 00111000001111 00110011111000 00110011100011 00110011100011 00110011001110	0000000	2 (8)	147 148 149 150 151 152 153	11000411001100 11000111100001 11000111110000 11001100000111 11001100011001 11001100011100	00000000
25	2 (A)	155 156 157 158 159 160	00110011000111 00110001111001 00110001110011 00110001110111 00110000111110	000000		155 156 157 158 159 160	11001100111000 11001110000011 11001110001100 11001110001100 11001110011000	000000
30		162 163 164 165 166 167	00111111100001 00111111001100 0011111100011 001111100011 00111110011001	2 2 2 2 2 2		161 162 163 164 168 166	11001111100000 11001111100110 1100111111	44444
35		168 169 170 171 172 173 174	00111110001110 00111110000111 00111100111100 0011110011001 00111100011110 00111100001111	2 2 2 2 2 2 2		168 169 170 171 172 173	11100011110011 11100011111001 11100011011	*****
40		178 176 177 178 179 180 181	00111001111100 001110011110011 001110011100111 00111000111110 00111000011111 0011000111111	2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2	3 (B)	175 176 177 178 179 180 181 182	11:00111100011 11:00111100110 11:00111110001 11:00111111000 11:0000011111 11:0000111110 11:0000110011	4442222
45		183 184 185 186 187 188	00110011110011 001100111001111 00110011	2 2 2 4 4 4		183 184 185 186 487 188	1110000111100 111000011000111 11100011000110 11100011100011	2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
50		189 190 191 192 193 194 195 196	00111111001110 00111110001111 001111100111110 001111000111110 00111100111111	4 4 4 4 4 4 6 6		189 190 191 192 193 194 195 196	11100011110001 11100011111000 111001100	2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
55		198	00111111001111	6		198	111001111100001	2 2

Table 17 (CDS \geq 0)

5			Table	17	(CD	s ≥ 0)	
	Class	8-bit data	Modulation codes beginning with "O"	CDS	Class	8-bit data	Modulation codes beginning with "1"	CDS
10	•	200 201 202 203 204 205	00011111110000 00011111100001 00011111000110 00011111000110 0001111000011	00000		200 201 202 203 204 208	1110000001111 11100000011110 11100000110011 11100000111001 111000011100	00000
15		205 207 208 209 210 211 212	00011110011001 00011110001110 0001111000111100 00011100111100 00011100110011	000000	3 (B)	206 207 208 209 210 211 212	11100001100110 11100001110001 111000011100011 11100011000110 11100011001100 1110001110001	000000
20	3 (A)	213 214 215 216 217 218 219	00011100001111 00011001111100 000110011	00000		213 214 215 216 217 218 219	11100011110000 11100110000011 111001100	000000
25		220 221 222 223 224 225 225	0001111110001 00011111100110 000111111001110 00011111001111 00011110001111	2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2		230 221 222 223 224 228 226	11110000001111 11110000011110 11110000110011 1111000011100 11110001100011	2 2 2 2 2 2 2 2 2
30		227 228 229 230 231 232 233	0001110011110 00011100011111 0001100111111	2 2 4 4 4 4 4 4	4 (B)	227 228 229 230 231 232 232	11110001110001 11110001111000 11110011000011 11110011001100 11110011100001 111100111100001	2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
35		294 238 236 237 238 239 240	0000111111000 0000111110010 0000111100110 00001111001110 00001111000111	000000		234 235 236 237 238 239 240	11110000000111 11110000011101 1111000011001 1111000011100 1111000111000 11110001110001	000000
40	4 (A)	241 242 243 244 245 246 247	000111001111 00001100111110 0001111111001 000111111	0 0 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2	-	241 242 243 244 245 246 247 248	11110001110000 11110011100000 1111100001110 1111100011100 11111000111000	2 2 2 2
45	5 (A)	248 249 250 251 252 253 254	0000111001111 0000011111100 00000111110011 00000111100111 00000111001111	0 0 0 0 0	5 (8)	249 250 251 252 253 - 254	1111001110000 11111000000011 11111000001100 11111000011000 11111000110000	0 0 0 0
	8 (A)	255	00000011111110	0	6 (8)	255	111111100000001	10

50

Table 18 (CDS \leq 0)

		8-bit	Modulation codes			8-bit	Modulation codes	
	Class	data	beginning with "0"	CDS	Class	data	beginning with "1"	CDS
5		0 1 2	01111110000001 0111110011000 01111100011000	000		0 1 2	10000001111110 10000011001111 10000011100111	000
10		3 6, 7 8 9	01111100001100 01111100000110 011111000000	0000000	·	3 4 5 6 7 8 9	10000011110011 10000011111001 100000111111	
15		11 12 13 14 15 16	01111000011001 01111000001110 01111000000	0000000		11 12 13 14 15 16	10000111100110 10000111110001 10000111111	00000
20		18 19 20 21 22 23 24	01110011000011 01110001111000 01110001110001 01110001100110 01110001111001 01110000111100			18 19 20 21 22 23	10001100111100 10001110000111 10001110001110 10001110011001 10001110011100 10001111000011	0000000
25	1 (C)	25 26 27 28 29 30	01110000110011 01110000011110 0111000000	000000	1 (D)	25 26 27 28 29 30 31	10001111001100 10001111100001 1000111111	0000000
30		32 33 34 35 36 37 38	01100111000011 01100110011100 011001100	000000		32 33 34 35 36 37 38	10011000111100 10011001100011 100110011	000000
35		39 40 41 42 43 44 45	01100011100110 011000111000111 01100011001111 011000111111	0000000		39 40 41 42 43 44 45	10011100011001 10011100011100 10011100110001 10011100111000 10011110000110 10011110001100 10011110001100	0000000
40		47 48 49 50 51 52	01100000111110 01100000011111 011111000000	0 -2 -2 -2 -2		47 48 49 50 51 52	100111111000001 100111111100000 10000000	0 -2 -2 -2 -2
45		53 54 55 56 57 58 59	01111000001100 01111000000110 01111000000	-2 -2 -2 -2 -2 -2		53 54 55 56 57 58 59	10000001111100 10000011000111 1000001100011 10000011100111 100000111,10001 10000011111000	-2 -2 -2 -2 -2 -2 -2 -2
50		60 61 62 63 64 65	01110000111000 01110000110001 01110000011100 0111000001100 0111000000	-2 -2 -2 -2 -2 -2 -2		60 61 62 63 64 65 66	10000110000111 10000110001110 100001100111001 10000110011100 10000111000110 1000011100110	-2 -2 -2 -2 -2 -2 -2 -2

Table 18 (CDS \leq 0)

5	Class	8-bit data	Modulation codes beginning with "0"	CDS	Class		Modulation codes beginning with "1"	CDS	
		67 68 69	01100111000001 01100110011000 011001100	2-2-2-		67 68 69	10000111100001 10000111110000 10001100000111	-2 -2 -2	
10		70 71 72 73 74 75	01100110000110 01100110000011 011000111100001 01100011100001 01100011000110	~~~~~~		70 71 72 73 74 75	10001100001110 10001100011001 10001100011100 10001100111000 10001110000011	-2 -2 -2 -2 -2 -2 -2 -2 -2 -2 -2 -2 -2 -	
15	1 (C)	76 77 78 79 80 81	01100011000011 01100001111000 0110000110001 01100001100011 011000011100 0110000011100	-2 -2 -2 -2 -2 -2 -2 -2		76 77 78 79 80 81	10001110000110 10001110001100 10001110011000 10001111000001 10011000000	******	
20		83 84 85 86	01100000110011 01100000011110 0110000001111 01100000111000 001111000000	-2 -2 -2 -4	1 (D)	83 84 85 86 87	10011000011001 10011000011100 10011000110001 10011000111000 10011001100001	******	
		88 89 90 91 92 93	0011100110000 0011100011000 0011100001100 0011100000110	*****		88 89 90 91 92 93	10011001110000 10011100000011 10011100000110 10011100001100 10011100011000		
25		94 95 96 97	00111000000011 001100111000001 00110011			94 95 96 97 98	10011110000001 10000000110011 10000000111001 1000000	-2 -4 -4 -4	
30	2 (C)	99 100 101 102 103 104	00110000110001 00110000011100 0011111000000	-4 -4 -2 -2 -2 -2		99 100 101 102 103 104	1000001100110 1000001110001 10000011100001 10000011000011 10000011000110	*****	
35		105 106 107 108 109 110	00111100000110 00111100000011 00111001110000 00111001110000 00111000110001	-2 -2 -2 -2 -2 -2 -2 -2 -2		105 106 107 108 109 110 111	10000011100001 10000011110000 10000110000011 10000110000110 1000011001100 10000111000001 1000011100000	-4 -4 -4 -4 -4	
40		112 113 114 115 116 117	00111000011001 00111000000111 001110011110000 001100111100001 00110011001100	-2 -2 -2 -2 -2 -2		113 114 115 116 117 118	10001100000011 1000110000110 10001100001100 10001100011000 10001100110000 1000111000000	-4 -4 -4 -4	
45		119 120 121 122 123 124 125	00110001100001 0011000111000 0011000111001 0011000110001 0011000111100 00110000111100	-2 -2 -2 -2 -2		119 120 121 122 123 124 125	10011000000011 .1001100000110 1001100001100 10011000011000 10011000110000 100111000000	-6 -6 -6 -6 -6	
5 0		126 127 128 129 130 131	00111111000001	-2 -2 0 0 0	2 (0)	126 127 128 129 130 131 132	1000000111000 10000001110000 10000011100000 11000000	0	

Table 18 (CDS \leq 0)

5			·,		·			
		8-bit	Modulation codes	ſ		8-bit	Modulation codes	
	Class	data	beginning	CDS	Class	data	beginning	CDS
			with "O"				with "1"	
		133	00111110000110	o l		133	11000001111001	0
	İ	134	00111110000011	0		134	11000001111100	ŏ
10		135	00111100111000	0		135	11000011000111	0
		136 137	00111100110001	0		136	11000011001110	0
		138	00111100011100	0		137 138	11000011100011	8
		139	00111100001110	ŏ		139	11000011100110	0
	'	140	00111100000111	ŏ	i	140	11000011111000	ŏ
		141	00111001111000	0		141	11000110000111	١ŏ١
15		142	00111001110001	. 0		142	11000110001110	0
		143	00111001100110	0		143	11000110011001	0
		144	00111001100011	0		144	11000110011100	0
		166	00111000111100.	0		146	11000111000011	0
		147	00111000110011	ŏ		147	11000111001100	ŏ
	2 (C)	148	00111000011110	Ò		148	11000111100001	ŏ
20		149	00111000001111	0		149	11000111110000	0
		150	00110011111000	0		150	11001100000111	0
		151 152	00110011110001	0		151 152	11001100001110 11001100011001	0
i		153	00110011100011	ŏ		153	11001100011100	ő
		154	00110011001110	Ŏ		154	11001100110001	ŏ
		155	00110011000111	.0		155	11001100111000	0
25		156	00110001111100	0		156	11001110000011	0
		157 158	00110001111001	0	2 (D)	157 158	11001110000110 11001110001100	0
	1	159	00110001100111	ŏ		159	11001110011000	6
	1	160	00110000111110	ŏ		160	11001111000001	0 1
	1	161	00110000011111	0		161	110011111100000	ŏ
	ł	162	00110000011001	-4		162	11000000011110	-2
30		163	00110000001110	-4		163	11000000110011	-2
		164	00110000000111	-4		164 165	11000000111001	-2
•		166	00011100110000	-4		166	11000000111100	-2 -2
	i	167	00011100011000	-4		167	11000001100110	-2
		168	00011100001100	-4		168	11000001110001	-2
	Ì	169	00011100000110	-4		169	11000001111000	-2
35	l	170	00011100000011	-4		170	11000011000011	-2
33	1	171 172	-00011001110000			171	11000011000110	-2
	1	173	00011001100001	-4		172 173	11000011001100	-2 -2
	1	174	00011000110001			174	11000011110000	-2
		175	00011000011100	-4		175	11000110000011	-2
	•	176	00011000011001	-4) ;	176	11000110000110	-2
40	3 (C)	177	00011000001110	1-4		177	11000110001100	-2
40	" (")	178 179	00011000000111	-4	1	178	11000110011000	-2
		180	00011111000001	-2	}	179 180	11000111000001	-2 -2
		181 .	00011110011000	-2	}	181	11001100000011	-2
	1	182	00011110001100	-2	I .	182	11001100000110	-2
		183	00011110000110	-2	1	183	11001100001100	-2
40	ĺ	184.	00011110000011	-2	1	184	11001100011000	-2
45	ł	186	00011100111000	-2 -2		185 -186	11001100110000	-2
		187	00011100011100	-2	1	187	11001110000001	-2 -4
	1	188	00011100011001	-2	l '	188	11000000011100	-4
		189	00011100001110	-2	1	189	11000000110001	-4
	!	190	00011100000111	-2	I :	190	11000000111000	-4
	1	191	00011001111000	-2		191	11000001100001	-4
50	1	193	00011001110001	-2 -2	1	192	11000001110000	-4
		194	00011001100110	-2	1	193 194	11000011000001	-4
		195	00011000111100	-2	l	195	11000110000001	-4
	l	196	00011000111001	-2		196	11001100000001	-4
	1	197	00011000110011	-2	ł	197	11000000011000	-6
	l	198	00011000011110	-2	1	198	11000000110000	-6
55	'	1 199	00011000001111	-2	<u> </u>	199	11000001100000	-6

Table 18 (QDS \leq 0)

_					•			
5		8-bit	Modulation codes			8-bit	Modulation codes	
	Class	data	beginning	CDS	Class	data	beginning	CDS
			with "0"				with "1"	
		200		0		200	11100000001111	0
		201	00011111110000	ă		201	11100000011110	ŏ
10		202	00011111001100	ō		202	11100000110011	0
		203	00011111000110	0		203	11100000111001	0
	j	204 205	00011111000011	0		204	11100000111100	0
		205	00011110011100	0		205 206	11100001100110	ŏ
		207	00011110001110	ŏ		207	11100001110001	ŏ
		208	00011110000111	0		208	11100001111000	0
15	3 (C)	209	00011100111100	0		209	11100011000011	0
		210 211	00011100111001	0		210 211	11100011000110	ŏ
		212	00011100011110	ŏ		212	11100011100001	0
		213	00011100001111	0		213	11100011110000	0
	•	214	00011001111100	0		214	111001100000011	0
	i	215 216	00011001111001	0		215 216	11100110000110	6
20		217	00011001100111	ŏ	3 (D)	217	11100110011000	ŏ
	l	218	00011000111110	ŏ		218	11100111000001	0
		219	00011000011111	0		219	11100111100000	-2
		220	00001111110000	-2 -2	1	220 221	11100000001110	-2
		222	00001111001100	-2	i	222	11100000011100	-2
25	i	223	00001111000110	-2		223	11100000110001	-2
25	ł	224	00001111000011	-2	1	224	11100000111000	-2 -2
	İ	225 226	00001110011100	-2 -2		225 226	11100001110000	-2
	1	227	00001110001110	-2	1	227	11100011000001	-2
	l	228	00001110000111	-2		228	11100011100000	-2
	1	229 230	00001100111100	-2	ł	229 230	11100110000001	-2 -6
30	4 (C)	231	00001100111001	-2 -2		231	11100000011000	-4
	}	232	00001100011110	-2	ì	232	11100000110000	-4
	1	233	00001100001111	-2	<u> </u>	233	11100001100000	-4
	l	234	00001111111000	0	1	234 235	11110000000111	8
	i	236	00001111110001	0	i	236	11110000011001	l ŏ l
•		237	00001111100011	6	1	237	11110000011100	Ŏ
35	1	238	00001111001110	Ö	I	238	11110000110001	9
	1	239	00001111000111	0	1	239	11110000111000	
	1	241	00001110011110	0	4 (D)	241	11110001110000	l ŏ l
	1	242	00001100111110	l ŏ		242	11170011000001	0
		243	00001100011111	<u>Là</u>		243	11110011100000	0
40		245	00000111111000	-2		244	11110000000110	-2 -2
40		246	00000111100011	-2 -2		245	11110000011000	-2
	1	247	00000111000111	-2	i	247	11110000110000	-2
	5 (C)	248	00000110001111	-2		248	11110001100000	-2
		249	00000111111100	0	1	250	11111000000011	١٥١
	1	251	00000111110011	1 %	5 (D)	251	11111000001100	Ò
45	1	252	00000111100111	0	1 " (0)	252	11111000011000	0
	1	253	00000111001111	0	i	253	11111000110000	8
	676	254	00000110011111	10	+	254	111111001100000	+ *
	6 (C)	255	00000011111110		8 (D)	255	1	

Types of the modulation codes that are allowed to take place according to the end pattern of the preceding modulation code are shown in Table 19.

TABLE 19

	γ 												
		01	be	" bi: ginn:	ts at	t the			of ": be	l" b. egin	its a	at t	he
88	CDS ≧ 0	1 (A)	2 (A)	3 (A)	4 (A)	5 (A)	6 (A)	1 (B)	2 (B)	3 (B)	4 (B)	5 (B)	6 (B)
1	CDS ≦ 0	1 (C)	2 (C)	3 (C)	4 (C)	5 (C)	6 (C)	1 (D)	2 (D)	3 (D)	4 (D)	5 (D)	6 (D)
at	110	0	0	0	0	0	0						
modu	1100	0	0	0	0	0			0	0	0	0	0
1	11000	0	0	0	0				0	0	0	0	0
peced	110000	0	0	0					0	0	0	0	0
	1100000	0	0						0	0	0	0	0
of th	001							0	0	0	0	0	0
ern	0011		0	0	0	0	0	0	0	0	0	0	
patt	00111		0	0	0	0	0	0	0	0	0		
End	001111		0	0	0	0	0	0	0	0			
	0011111		0	0	0	0	0	0	0				
	pattern of the preceding modulation code	End pattern of the preceding modulation code of the preceding modulation code color con code code code code code code code code	End pattern of the preceding modulation codes of the preceding modulation	End pattern of the modulation	CDS≥0	CDS≥0	of "0" bits at the beginning of modulation code CDS≥0	CDS≥0	CDS≥0	CDS≥0	CDS≥0	CDS≥0	CDS≥0

"o" mark indicates that the modulation codes are allowed.

For example, when the end pattern of the preceding modulation code is "...11000", and the end DSV of the preceding modulation code is -4, the modulation codes of classes 1(A), 2(A), 3(A), 4(A), 2(B), 3(B), 4(B), 5(B) and (6B) in Table 17 can take place as a current modulation code.

In this case, suppose that the current 8-bit data is "166". Then, one of the two possible modulation codes "00111110011100" (CDS = 2; 2(A)), and "11100011001111" (CDS = 4; 2(B)) is selected: the end DSV at the end of the preceding modulation code and the CDS of the current modulation code are added so as to obtain the end DSV at the end of the current modulation code; the modulation code which will give less DSV is selected, that is, the modulation code "11100011001111" (CDS = 4) is selected. The resultant DSV is 0 and it indicates that the direct current component is removed.

Fig. 3A shows the CNR (carrier-to-noise ratio) characteristics when a sine wave recorded on magnetic tape is reproduced, Fig. 3B shows the power spectrum at the output terminal of the modulator of the embodiment when random 8-bit data are inputted to the modulator, and Fig. 3C shows the power spectrum of the scrambled NRZ at the output terminal of the scrambled NRZ modulator when random 8-bit data are inputted to the scrambled NRZ modulator.

As described above, the embodiment restricts the number of consecutive identical bits in a stream of modulation codes to 2 - 7. As a result, the minimum magnetization transition width is 1.14T (= (2 × 8)T/14, where T is the bit period of the 8-bit data), the maximum magnetization transition width is 4.00T (= (7 × 8)-T/14), DR is 1.14 (= (2 × 8)/14), and the ratio of the maximum magnetization transition width to the minimum magnetization transition width is 3.5. Consequently, the bit error rate of the magnetic recording is reduced, and the high-density recording becomes possible. In addition, azimuth recording and high quality over-writing become possible.

Furthermore, the embodiment restricts the absolute value of CDS of the modulation codes equal to or less than 6, allocates up to 4 modulation codes to each 8-bit data according to the DSV at the end of the preceding modulation code and the end pattern of the preceding code, and selects the modulation code the DSV of which gives the least absolute value. As a result, the maximum value of the absolute value of the end DSV can be restricted within 4. Thus, the direct current component can be effectively removed, and hence, the transmission of the modulation codes becomes possible by using a rotary transformer that does not pass the direct current component.

Although specific embodiments of a digital modulation method in accordance with the present invention have been disclosed, it is not intended that the invention be restricted to either the specific configurations or the uses disclosed herein. Modifications may be made in a manner obvious to those skilled in the art. Accordingly, it is intended that the invention be limited only by the scope of the appended claims.

A digital modulation method for modulating 8-bit digital data into 14-bit digital modulation codes. The number of consecutive identical bits in a series of 14-bit digital modulation codes is restricted to 2 - 7. The absolute value of DSV at the end of each 14-bit digital modulation code is restricted to 2 or less, and the absolute value of DSV at each bit of any 14-bit digital modulation codes is limited to 7 or less. The direct current component of the 14-bit modulation codes can be effectively reduced.

Claims

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1. A digital modulation method for converting 8-bit digital data into 14-bit digital modulation codes, said digital modulation method characterized by comprising:

step 1 for selecting up to four 14-bit digital modulation codes for each 8-bit digital data, said 14-bit digital modulation code is selected by the procedures of

(a) selecting among the 2¹⁴ 14-bit digital codes, a digital code the numbers of consecutive identical bits in which are 5 or less in the first 6 bits, 2 - 7 from the second bit to 13th bit, and 6 or less in the last 7 bits, the absolute value of CDS (code word digital sum) of the selected digital code being 4 or less, and repeating this selecting procedure,

(b) selecting among the selected 14-bit digital codes at the procedure (a), a digital code the first bit of which is "0", and the value of CDS of which is 0, and pairing the selected 14-bit digital code with the reversal code thereof to make the 2 digital codes one group, or selecting among the selected 14-bit digital codes at the procedure (a), a digital code the first bit of which is "1", and the value of CDS of which is +2 or +4, combining the selected 14-bit digital codes with the reversal codes thereof, and further combining the two 14-bit digital codes with a pair of 14-bit digital codes selected at the above procedure to make the 4 digital codes one group, and repeating this selecting procedure,

(c) selecting among the selected 14-bit digital codes at the procedure (a), a digital code the first bit of which is "0", and the value of CDS of which is +2, and another digital code the first bit of which is "1", and the value of CDS of which is +2 or +4, and combining the two selected 14-bit digital codes with the reversal codes thereof to make the 4 digital codes one group, and repeating this selecting procedure,

(d) selecting among the selected 14-bit digital codes at the procedure (a), a digital code the first bit of which is "0", and the value of CDS of which is +4, and another digital code the first bit of which is "1", and the value of CDS of which is +2, and combining the two selected 14-bit digital codes with the reversal codes thereof to make the 4 digital codes one group, and repeating this selecting procedure, and

(e) selecting 256 groups among the groups formed in the above procedures as the 14-bit digital modulation codes;

step 2 for selecting one group of 14-bit digital modulation codes among the 256 groups of the 14-bit

digital modulation codes, the selected group corresponding to inputted 8-bit digital data;

step 3 for further selecting one or more 14-bit digital modulation codes in the selected group at step 2, each of the 14-bit digital modulation codes satisfying the requirement that the number of consecutive identical bits at the joint portion of the preceding 14-bit digital modulation code already selected and the 14-bit digital modulation code to be selected is 2 - 7; and

step 4 for further selecting one 14-bit digital modulation code among the selected modulation codes at step 3 so that said one 14-bit digital modulation code satisfies the requirement that the absolute value of bit DSV (Digital Sum Value) for each bit in the modulation code is equal to or less than 7.

2. A digital modulation method as claimed in claim 1, characterized in that said step 3 comprises the procedures of:

selecting any one of the digital modulation codes the first bits of which are "01", "001", "0001", "00001", and "000001" when the preceding digital modulation code that has already been selected terminates with "10".

selecting any one of the digital modulation codes the first bits of which are "10", "110", "1110", and "111110" when the preceding digital modulation code that has already been selected terminates with "01".

selecting any one of the digital modulation codes the first bits of which are "110", "1110", "11110", "001", "001", "0001", "00001", and "000001" when the preceding digital modulation code that has already been selected terminates with "100";

selecting any one of the digital modulation codes the first bits of which are "001", "0001", "00001", "000001", "10", "1110", "11110", and "1111110" when the preceding digital modulation code that has already been selected terminates with "011";

selecting any one of the digital modulation codes the first bits of which are "110", "1110", "11110", "11110", "001", "0001", and "00001" when the preceding digital modulation code that has already been selected terminates with "1000";

selecting any one of the digital modulation codes the first bits of which are "001", "0001", "00001", "000001", "110", "1110", and "11110" when the preceding digital modulation code that has already been selected terminates with "0111";

selecting any one of the digital modulation codes the first bits of which are "110", "11110", "11110", "01", "001", and "0001" when the preceding digital modulation code that has already been selected terminates with "10000":

selecting any one of the digital modulation codes the first bits of which are "001", "0001", "00001". "000001", "10", "110", and "1110" when the preceding digital modulation code that has already been selected terminates with "01111";

selecting any one of the digital modulation codes the first bits of which are "110", "1110", "11110", "11110", "01", and "001" when the preceding digital modulation code that has already been selected terminates with "100000";

selecting any one of the digital modulation codes the first bits of which are "001", "00001", "000001", "10", and "110" when the preceding digital modulation code that has already been selected terminates with "0111111";

selecting any one of the digital modulation codes the first bits of which are "110", "1110", "11110", "111110", and "01" when the preceding digital modulation code that has already been selected terminates with "1000000"; and

selecting any one of the digital modulation codes the first bits of which are "001", "0001", "00001", and "10" when the preceding digital modulation code that has already been selected terminates with "01111111";

3. A digital modulation method as claimed in claim 1, characterized in that said step 4 comprises the procedures of:

selecting any one of the digital modulation codes the CDS of which are 0, -2 and -4, when the DSV at the end of the preceding 14-bit digital modulation code that has already been selected is +2; selecting any one of the digital modulation codes the CDS of which are +2, 0 and -2, when the DSV at the end of the preceding 14-bit digital modulation code that has already been selected is 0; and selecting any one of the digital modulation codes the CDS of which are +4, +2, and 0 when the DSV at

the end of the preceding 14-bit digital modulation code that has already been selected is -2;

4. A digital modulation method as claimed in claim 1, characterized in that said digital modulation codes obtained at step 1 are the codes described in the following Tables 4 and 5, or the codes obtained by substituting a part of Table 4 by the following Table 12, or the codes obtained by substituting a part of Table 5 by the following Table 13.

Table 4 (CDS \geq 0)

	Class	8-bit data	Modulation codes beginning with "O"	CDS	Class	8-bit data	Modulation codes beginning with "1"	CDS
5		0 1 2	01111110000001 01111100110000 01111100011000	000		0 1 2	10000001111110 10000011001111 10000011100111	0 0
10		2 3 4 5 6 7 8	01111100001100 01111100000110 011111000000	000000		2 3 4 5 6 7 8	1000001111001 10000011111001 1000011000111 10000110001110 1000011000111	0 0 0
15		9 10 11 12 13 14	01111000110001 01111000011001 01111000011001 01111000001110 01111000000	000000	-	9 10 11 12 13 14	10000111001110 10000111100011 10000111100110 10000111110001 10000111111	000000
20		16 17 18 19 20 21	01110011001100 01110011000110 01110011000011 01110001111000 01110001110001	00000		16 17 18 19 20 21	10001100110011 10001100111001 10001100111100 1000111000111 10001110001100 1000111001100	000000
25		22 23 24 25 26 27 28	01110001100011 01110000111001 01110000110011 0111000011011	000000		23 24 25 26 27 28	10001111000011 10001111000110 10001111001100 10001111100001 1000111111	0 0 0 0
30	1 (A)	29 30 31 32 33 34	01100111100001 01100111001100 01100111000110 01100111000011 01100110011100	0 0 0 0	1 (B)	29 30 31 32 33 34 35	10011000011110 10011000110011 10011000111001 10011001100011 10011001100110	000000
35		35 36 37 38 39 40 41	01100110001110 01100110000111 01100011111000 01100011100011 0110001100011	0		36 37 38 39 40 41	10011001111000 10011100000111 10011100001110 10011100011001 10011100011100	00000
40		42 43 44 45 46	01100011900111 01100001111100 01100001111001 01100001110011 01100000111110	00000		42 43 44 45 46 47	10011100111000 10011110000011 10011110000110 10011110001100 10011110011000	00000
45		48 49 50 51 52 53	01100000011111 01111111001100 011111111	4 4 4 4		48 49 50 51 52 53	10011111100000 100000111111110 10000110011111 10000111001111 10000111100111	0 2 2 2 2 2 2 2 2
50		54 55 56 57 58 59	01111110001110 0111111000111100 01111100111100 0111110011001	4 4 4		54 55 56 57 58 59 60	10000111111001 10000111111100 10001100011111 100011100111110 10001110011110	******
55		60 61 62 63	0111110000111 01111001111100 0111100111100	1 4		61 62 63	10001111001110 10001111100011 10001111100110	2 2 2

Table 4 (CDS ≥ 0)

	Class	8-bit	Modulation codes	CDS	Class	8-bit	Modulation codes	CDS
5		64 .65	beginning with "0" 01111001100111 01111000111110	4		data 64	beginning with "1" 10001111110001	2
•		66 67	01111000011111	444		65 66 67	10001111111000 10011000011111 10011000111110	2 2 2
10		68 69 70	01110011111001 01110011110011 01110011100111	444		68 69 70	10011001100111 10011001110011 10011001111001	2 2 2
10		71 72 73	01110011001111 01110001111110 01110000111111	444		71 72 73	10011001111100	2 2
		74 75	01100111111100	4		74 75	10011100011110 10011100110011 10011100111001	2 2 2
15		76 77 78	01100111110011	٥٠٠		76 77 78	10011100111100 10011110000111 10011110001110	2 2 2
		79 80 81	01100110011111 01100011111110 01111111000001	4 4 2	1 (B)	79 80 81	10011110011001 10011110011100 10011111000011	222222222222222224
20		82 83 84	01111110011000 01111110001100 011111110000110	**************	. !	82 83 84	100111111000110	2 2
		85 86	01111110000011	222		85 86	10011111100001 10011111110000 10001111001111	2
25		87 88 89	01111100110001 01111100011100 01111100011001	2 2		87 88 89	10001111100111 100011111110011 10011001	4
23		90 91. 92	01111100001110	2 2 2		90 91 92	10011100141110	4
		93 94 95	01111001110001 01111001100110 01111001100011	2 2 2		93 94 95	10011111000111 10011111001110 10011111100011	4
30	1 (A)	96 97	01111000111100	2		96 97	10011111100110	4
	ן נאו	98 99 100	01111000110011 01111000011110 01111000001111	2 2 2 2		98 99 100	11000111110011 11000000111111 1100000111111	2 2
35		101 102 103	01110011111000 01110011110001 01110011100110	2 2 2		101 102 103	11000011001111 11000011100111 11000011110011	2 2 2 2
		104 105 106	01110011100011 01110011001110	22222222		104 105 106	11000011111001	2 2
40		107 108	01110011000111 01110001111100 01110001111001	2 2	2 (B)	107 108	11000110001111 11000110011110 11000111000111	2 2
		109 110 111	01110001110011 01110001100111 01110000111110	2	2 (0)	109 110 111	11000111001110 11000111100011 11000111100110	222,2222
		112 113 114	01110000011111	2 2 2		112 113 114	11000111110001 11000111111000 11001100001111	2
45		115 116 117	01100111100110 01100111100011 01100111001110	2 2		115 116 117	11001100011110	2 2
		118 119	01100111000111 01100110011110	2 2 2		118 119	11001100111001 11001100111100 11001110000111	22222222222
50		120 121 122	01100110001111	2 2 2		120 121 122	11001110001110 11001110011001 11001110011100	2 2 2
		123 124 125	01100011110011 01100011100111 01100011001111	2 2 2		123 124	11001111000011 11001111000110 11001111001100	2 2
55		126 127	011000011111110 011000001111111	2 2		125 126 127	110011111100001	2 2 2

Table 4 (CDS ≥ 0)

	Class	8-bit data	Modulation codes beginning with "O"	CDS	Class	8-bit data	Modulation codes · beginning with "l"	CDS	
5		128 129	00111111100000	00		128 129	11000000011111	00	
		130 131 132 133	00111110011000 00111110001100 00111110000110	0000		130 131 132 133	11000001100111 11000001110011 11000001111001 11000001111100	0000	
10		134 135 136 137	00111100111000 00111100110001 00111100011100 00111100011001	0000		134 135 136 137	11000011000111 11000011001110 11000011100011 11000011100110	0000	
15		138 139 140 141 142	00111100001110 00111100000111 00111001111000 00111001110001	0000		138 139 140 141 142	11000011110001 11000011111000 11000110000111 11000110001110	0000	
		143 144 145 146	00111001100110 00111001100011 00111000111100 00111000111001	00000	2 (8)	143 144 145 146	11000110011001 11000110011100 1100011100011 11000111000110	0 0 0	
20		147 148 149 150	00111000011110 00111000001111 00110011111000 00110011110001	0000		147 148 149 150	11000111100001 11000111110000 11001100000111 11001100001110	0000	
25		151 152 153 154 155	00110011100110 00110011100011 001100110	00000		151 152 153 154 155	11001100011001 11001100011100 110011001	00000	
30		156 157 158 159 160	00110001111001 00110001110011 00110001100111 00110000111110	00000		156 157 158 159 160	11001110000110 11001110001100 11001110011000 11001111000001	0 0 0	
	2(A)	161 162 163 164	00111111100001 001111111001100 001111111	2222		161 162 163 164	11001100111110 11001110011110 11001111000111 11001111001110	444	
35		165 166 167 168 169	00111110011100 00111110011001 00111110001110 00111110000111	2222		165 166 167 168 169	11001111100011 11001111100110 1110000111111	4	
40		170 171 172 173 174	00111100111001 00111100111001 0011110011101 00111100001111 001110001111100 001110011111001	222222	3 (B)	170 171 172 173 174 175	11100011111100 11100110011110 11100111001111 11100111001110 1110011110011	4444	
45		176 177 178 179 180	00111001110011 00111001100111 00111000111110 001110000111111	2 2 2		176 177 178 179 160 181	11100111111000 11100000011111 11100000111110 11100001100111	42222	
50		181 182 183 184 185 186	00110011110011 00110011110011 001100110	22222224		182 183 184 185 186	11100001111001 111000011111000 111000110001110 11100011001110 1110001110011	2222222222222	
55		187 188 189 190	00111111100110	4444		187 188 189 190 191	11100011110001 11100011111000 111001100	2 2 2 2 2 2	
1	, ,		,	٠,	. 1			- 1	

Table 4 (CDS \geq 0)

	Class	8-bit data	Modulation codes beginning with "0"	CDS	Class	8-bit data	Modulation codes beginning with "1"	CDS
5	2 (A)	192 193 194 195 196	00111110001111 001111100111110 00111100111111	4444		192 193 194 195 196	11100110011100 11100111000011 11100111000110 11100111001100 11100111100001	2 2 2 2 2 2
10 .		197 198 199 200 201 202	0011001111110 00011111110000 00011111100001 00011111000110 0001111100011	40000	3 (B)	197 198 199 200 201 202	11100111110000 11100000001111 11100000011110 11100000110011 11100000111001	2 0 0 0 0 0 0
15		203 204 205 206 207 208	00011110011100 00011110011001 00011110001110 000111100011100 00011100111100	000000		203 204 205 206 207 208	11100001100011 11100001100110 11100001110001 1110001111000 11100011000110	0 0 0 0
20		209 210 211 212 213	00011100110011 00011100011110 00011100001111 00011001111100 00011001111001	000000		209 210 211 212 213 214	11100011001100 11100011100001 11100011110000 11100110000011 11100110000110	0 0 0 0 0
25	3 (A)	214 215 216 217 218 219	000110011100111 00011001110111 000110000111110 000111111	00022		215 216 217 218 219 220	11100110011000 11100111000001 11100111100000 11110001111100 111100111111	0 0
30	·	220 221 222 223 224 225 226	00011111100011 00011111001110 00011111001111 00011110001111 000111000111110 000111000111111	222222	4 (B)	221 222 223 224 225 226	11110000011110 11110000110011 11110000111001 11110000111100 11110001100011	22222
35		227 228 229 230 231 232	00011001111110 00011000111111 0001111111	224444	1,07	227 228 229 230 231 232	11110001110001 11110001111000 11110011000011 11110011000110 11110011001100	22222222222220
40	4 (A)	233 234 235 236 237 238 239	00011100111111 00001111111000 0000111111	400000		233 234 235 236 237 238 239	11110011110000 11110000000111 1111000001100 11110000011001 11110000110001 11110000110001	0 0 0 0
45		240 241 242 243 244 245	00001110011110 00001110001111 0000110011111 0000110001111 0000111111	000022	-	240 241 242 243 244 245	11110001100001 11110001110000 11110011000001 11110011100000111 11111000000	0 0 0 2 2
50		246 247 248 249 250	00001111100111 00001111001111 00001110011111 00001100111111	2 2 2 2 0	5 (B)	246 247 248	11111000011001 11111000011100 11111000111000 11111001110000 11111000000	22220
55	5 (A)	251	00000111111001 00000111110011 00000111100111 00000111001111	0 0 0		251 252 253 254 255	11111000000110 1111100001100 1111100011000 1111100110000	0000

Table 5 (CDS \leq 0)

	[.]	8-bit	Modulation codes	coc		8-bit	Modulation codes	CDC
	Class	data	beginning with "0"	CDS	Class	data	beginning with "1"	CDS
5		0	01111110000001	0		0	10000001111110	0
		2	01111100011000	0		1 2	10000011001111	0
		3 4	01111100001100	0		3 4	10000011110011	0
		5	01111100000011	ŏ		5	10000011111100	0
10		6	01111001110000	0		6	10000110001111 10000110011110	0
		8	01111000111000	0		8	10000111000111	0
	1	9 10	01111000110001	0		9 10	10000111001110 10000111100011	0
		11	01111000011001	0		11 12	10000111100110	0
15	1	12 13	01111000000111	00		13	10000111111000	0
	ĺ	14 15	01110011110000	0		14 15	10001100001111 10001100011110	0
		16	01110011001100	0		16	10001100110011	0
	l	17 18	01110011000110	0		17 18	10001100111001 10001100111100	0
20]	19	01110001111000	0		19 20	10001110000111	0
		20 21	01110001110001	0		21	10001110011001	0
		22 23	01110001100011	.0		22 23	10001110011100 10001111000011	0
		24	01110000111001	0		24	10001111000110	00
25		25 26	01110000110011	0	1	25 26	10001111001100	0
	1	27	01110000001111	0		27 28	10001111110000	0
		28 29	01100111100001	0		29	10011000011110	0
		30 31	01100111001100	0		30 31	10011000110011	0
30		32	01100111000011	0		32	10011000111100	0
	1 (C)	33 34	01100110011100	0	1 (D)	33 34	10011001100011 10011001100110	00
	```	35	01100110001110	0	- \-/	35	10011001110001	0
		36 37	01100110000111	0		36 37	10011001111000	0
35		38	01100011110001	0		38 39	10011100001110	0
		39 40	01100011100110	0		40	10011100011100	0
		41	01100011001110	0		41	10011100110001	0
		42	01100001111100	0		43	10011110000011	0
40	1	45	01100001111001			44	10011110000110	0
		46	01100001100111	0		46	10011110011000	0
	1	48	01100000111110	0		47 48	100111111000001	Ó
		49	01111100000001	-2 -2		49 50	10000000110011	-4 -4
45		50 51	01111000110000	-2		51	10000000111100	-4
-		52 53	01111000011000	-2   -2		52 53	10000001100011	-4
		54	[01111000000110	-2	•	54	10000001110001	-4
		55 56	01111000000011	-2   -2	l	55 56	10000001111000	-4
50		57	01110011000001	-2		57	10000011000110	-4
		58 59	01110001110000	-2 -2		58 59	10000011001100	-4
		60	01110000111000	-2		60	10000011110000	-4
		61	01110000110001	-2   -2		61	10000110000011	-4
<i></i>		63	01110000011001	-2		63	10000110001100	-4
55	•		t.	•			1	

Table 5 (CDS  $\leq$  0)

	Class	8-bit data	Modulation codes . beginning with "0"	COS	Class	8-bit data	Modulation codes beginning with "1"	CDS
5		64	01110000001110	-2		64	10000110011000	-4
		65 66	01110000000111	-2		65 66	10000111000001	-4
_		67 68 69	01100111000001 01100110011000 011001100	-2		67 68	10001100000011	-4
10		70 71	01100110000110	-2 -2		69 70 71	10001100001100   10001100011000   10001100110000	-4 -4
		72 73	01100011110000	-2		72 73	10001110000001	-4
		74 . 75	01100011001100	-2 -2		74 75	10011000000011	-4
15		76 77	01100011000011	-2		76 77	10011000001100	-4
	1 (C)	78 79	01100001110001	-2 -2		78 79	10011000110000	-4
		80 81	01100001100011	-2 -2		80 81	10011100000001	-2
20		82 83 84	01100000111001	-2 -2		82 83 84	10000001100111 10000001110011 10000001111001	-2 -2 -2
		85 86	01100000001111	-2 -4		85 86	10000001111100	-2 -2
		87 88	01110000011000	-4-4		87 88	10000011001110	-2 -2
25		89 90	01100110000001	-4		89 90	10000011100110	-2
		91 92 93	01100001110000	-4		91 92 93	10000011111000 10000110000111 10000110001110	-2 -2 -2
		94 95	01100000110001	-4		94 95	10000110011001	-2 -2
30		96 97	01100000011001	-4		96 97	10000111000011	-2 -2
		98 99	00111000001100	-4 -2	1 (D)	98 99	10000111001100	-2
. 35		100	00111110000001	-2		100 101 102	10000111110000	-2
33		102 103 104	00111100011000	-2 -2 -2		103	10001100001110 10001100011001 10001100011100	-2 -2 -2
		105	00111100000011	-2 -2		105 106	10001100110001 10001100111000	-2 -2
40		107 108	00111001100001	-2 -2		107	10001110000011	-2 -2
10		109 110	00111000110001	-2		109 110	10001110001100 10001110011000	-2 -2
	2 (C)	111	00111000011001	-2 -2		111	10001111000001	-2 -2
45		113 114 115	001110000000111 00110011110000 00110011	-2 -2		113 114 115	10011000000111 10011000001110 10011000011001	-2 -2
		116 117	001100111001100	-2 -2 -2		116	10011000011100	-2 -2 -2
		118 119	00110011000011	-2 -2		118 119	10011000111000 10011001100001	-2 -2
50		120 121	00110001110001	-2 -2		120 121	10011001110000 10011100000011	-2 -2
		122 123	00110001100011	-2 -2		122 123	10011100000110	-2 -2
		124 125	00110000111001	-2 -2		124	10011100011000	-2 -2
55		126 127	001100000011110	-2 -2		126 127	10011110000001	-2 -2

Table 5 (CDS  $\leq$  0)

ı		8-bit	Modulation codes	000		8-bit	Modulation codes	CDS
	Class	data	beginning with "0"	CDS	Class	data	beginning with "1"	7.00
5		128	00111111100000	0		128	11000000011111	0
•		129 130	00111111000001	0		129 130	1110000001111110	ŏ
		131	00111110001100	ŏ	i	131	11000001110011	0
		132	00111110000110	0		132	11000001111001	0
		133 134	00111110000011	0		133 134	11000011000111	ŏ
10		135	00111100110001	ŏ		135	11000011001110	0
		136	00111100011100	0		136 137	11000011100011	0
		137 138	00111100011001	0		138	11000011110001	ŏ
	'	139	00111100000111	Ŏ		139	11000011111000	0
15		140	00111001111000	0		140	11000110000111	0
15		141	00111001110001	0		142	11000110011001	0
	2 (C)	143	00111001100011	0		143	11000110011100	0
		144	00111000111100	0		144	11000111000011	ö
	1	146	00111000110011	ŏ		146	11000111001100	0
20		147	00111000011110	0		147	11000111100001	0
	ŀ	148	00111000001111	0	•	149	11001100000111	0
	1	150	00110011110001	0		150	11001100001110	0
		151	00110011100110	0		151 152	11001100011001	0
		152 153	00110011100011	l ö	1	153	11001100110001	0
25		154	00110011000111	0		154	11001100111000	8
	1	155	00110001111100	0		155 156	11001110000011	ŏ
		156 157	00110001111001			157	11001110001100	0
	ĺ	158	00110001100111	0		158	11001110011000	0
00	ł	159	00110000111110	0		159	11001111100000	ŏ
30	1	160	00110011000001	-4		161	11000000011110	-2
		162	00110001100001	-4	2(D)	162	11000000110011	-2 -2
	1	163	00110000111000	-4		164	11000000111100	-2
	ł	164	00110000110001	-4		165	11000001100011	-2
35		166	00110000011001	-4	1	166	11000001100110	-2 -2
		167	00011110000001	-4	l	168	11000001111000	-2
	İ	168	00011100001100	-4.	1	169	11000011000011	-2
	1	170	00011100000011	-4	l	170	11000011000110	-2 -2
		171	00011001100001	-4		172	11000011100001	-2
40		172	00011000111000	-4		173	11000011110000	-2
		174	00011000011100		1	174	11000110000011	-2 -2
	3 (C)	175	00011000011001			176	11000110001100	-2
	1	177	00011111100000	-2	i	177	11000110011000	-2 -2
	1	178	00011111000001		l	178	11000111000001	-2
45		179	00011110011000		i	180	11001100000011	-2
		181	00011110000110	-2	1	181	110011.00000110	-2 -2
	1	182	00011110000011		•	182 183	11001100001100	-2
		183	00011100111000		1	184	11001100110000	-2
50		185	00011100011100	-2	1	185	11001110000001	-2
30		186	00011100011001		1	186	110011111000000	-2 -4
		187	00011100001110			188	11000000011100	-4
		188	00011001111000		1	189	11000000110001	-4
		190	00011001110001	-2	1	190	11000000111000	-4
55	1	191	00011001100110	-2	ļ	'7'		•
	•	•	•	•	-			

Table 5 (CDS  $\leq$  0)

	2222	8-bit	Modulation codes	CDC	2)	8-bit	Modulation codes	600
5	Class	data	beginning with "0"	CDS	Class	data	beginning with "1"	CDS
·		192	00011001100011	-2		192	11000001110000	-4
		193 194	00011000111100	-2 -2		193 194	11000011000001	-6
		195	00011000110011	-2		195	11000110000001	-4
		196	00011000011110	-2	2(D)	196	11000111000000	-4
10		197 198	00011000001111	-2 0		197 198	11001100000001	-
		199	00011111100001	Ō		199	11100000011110	ŏ
		200 201	00011111001100	0		200 201	11100000110011	0
	3 (C)	202	00011111000011	0		202	11100000111001   11100000111100	00
	1	203	00011110011100	0		203	11100001100011	0
15		204 205	00011110011001	0		204	11100001100110   11100001110001	0
		206	00011110000111	Ŏ		206	11100001111000	ŏ
		207	00011100111100	0		207 208	11100011000011	0
		208 209	00011100111001	0		209	11100011000110   11100011001100	0
20		210	00011100011110	0		210	11100011100001	0
20	· ·	211 212	00011100001111	0		211 212	11100011110000	0
		213	00011001111001	Ö		213	11100110000110	ŏ
	·	214	00011001110011	0		214	11100110001100	0
		215 216	00011001100111	0	3 (D)	215 216	11100110011000 11100111000001	0
25	_	217	00011000011111	0		217	11100111100000	0
		218	00001110000011	-4		218	11100000001110	-2.
		219 220	00001100000111	-4 -2		219 220	11100000011001	-2 -2
		221	00001111100001	-2		221	11100000110001	-2
		222 223	00001111001100	-2 -2		222 223	11100000111000 11100001100001	-2 -2
30		224	00001111000011	-2		224	11100001110000	-2
		225	00001110011100	-2		225	11100011000001	-2
	4 (C)	226 227	00001110011001	-2 -2		226 227	11100011100000   11100110000001	-2 -2
		228	00001110000111	-2.		228	11100111000000	-2
		229	00001100111100	-2		229 230	11100000001100	-4
35		230 231	00001100111001	-2 -2		231	11100000110000	-4
		232	00001100011110	-2		232	11100001100000	-4
		233 234	00001100001111	-2		233 234	11100011000000	-6
		235	00001111110001	0		235	11110000001110	ŏ
40		236	00001111100110	0		236	11110000011001	0
		237 238	00001111100011	0		237 238	11110000011100	0
		239	00001111000111	0		239	11110000111000	0
		240	00001110011110	0.		240	11110001100001	0
		241 242	00001110001111   00001100111110	0	4 (D)	241 242	11110001110000 11110011000001	0
45		243	00001100011111	0	10,	243	11110011100000	0
		244	00000111111000	-2		244 245	11110000000110   11110000001100	-2 -2
		245 246	00000111110001	-2 -2		246	11110000011000	-2
		247	00000111100011	-2		247	11110000110000	-2
		248	00000111000111	-2		248 249	11110001100000 11110011000000	-2 -2
50	5 (C)	249 250	00000110001111	-2 0		250	11111000000011	6
	,	251	00000111111001	0		251	11111000000110	0
		252	00000111110011	0	5 (D)	252 253	111111000001100	0
		253 254	0000011100111	0	V (D)	253 254	111111000110000	0
55		255	00000110011111	Ŏ		255	11111001100000	Ō
<i>5</i> 5							l	لــــا

TABLE 12

8-bit data	Modulation codes	CDS
248	11111000110001	2
249	11111000111000	2
250	11111001100001	2
251	11111001110000	2

TABLE 13

		_
8-bit data	Modulation codes	CDS
248	00000111001110	-2
249	00000111000111	-2
250	00000110011110	-2
251	00000110001111	-2

- 5. A digital modulation method for converting 8-bit digital data into 14-bit digital modulation codes, said digital modulation method comprising:
- step 1 for selecting up to four 14-bit digital modulation codes for each 8-bit digital data, said 14-bit digital modulation code is selected by the procedures of
- (a) selecting among the 2¹⁴ 14-bit digital codes, a digital code the numbers of consecutive identical bits in which are 6 or less in the first 7 bits, 2 7 from the second bit to 13th bit, and 5 or less in the last 6 bits, and repeating this selecting procedure,
- (b) selecting among the 14-bit digital codes selected at the procedure (a), a digital code the first bit of which is "0", and the CDS of which has the absolute value equal to or less than 6, and repeating this selecting procedure,
  - (c) selecting among the 14-bit digital codes selected at the procedure (a), a digital code the first bit of which is "1", and the CDS of which has the absolute value equal to or less than 4, and repeating this selecting procedure,
  - (d) selecting among the 14-bit digital codes selected at the procedure (b), a digital code the value of CDS of which is 0, and pairing the selected 14-bit digital code with the reversal code thereof to make the 2 digital codes one group, and repeating this selecting procedure,
  - (e) selecting among the 14-bit digital codes selected at the procedure (b), a digital code the value of CDS of which is +2, +4 or +6, selecting among the 14-bit digital codes selected at the procedure (c), a digital code the value of CDS of which is +2 or +4, and combining the two selected 14-bit digital codes with the reversal codes thereof to make the 4 digital codes one group, and repeating this selecting procedure, and
  - (f) selecting 256 groups among the groups formed in the above procedures as the 14-bit digital modulation codes;
  - step 2 for selecting one group of 14-bit digital modulation codes among the 256 groups of the 14-bit digital modulation codes, said selected group corresponding to inputted 8-bit digital data;

- step 3 for further selecting one or more 14-bit digital modulation codes in the selected group at step 2, each of the 14-bit digital modulation codes satisfying the requirement that the number of consecutive identical bits at the joint portion of the preceding 14-bit digital modulation code already selected and the 14-bit digital modulation code to be selected is 2 7; and
  - step 4 for further selecting one 14-bit digital modulation code among the selected modulation codes at step 3 so that said one 14-bit digital modulation code satisfies the requirement that the absolute value of bit DSV for each bit in the modulation code is equal to or less than 8.
  - 6. A digital modulation method as claimed in claim 5, wherein said step 3 comprises the procedures of: selecting any one of the digital modulation codes the first bits of which are "01", "001", "0001", "00001", and "0000001" when the preceding digital modulation code that has already been selected terminates with "10";
  - selecting any one of the digital modulation codes the first bits of which are "10", "110", "1110", "11110", "111110", and "1111110" when the preceding digital modulation code that has already been selected terminates with "01";
  - selecting any one of the digital modulation codes the first bits of which are "110", "1110", "11110", "111110", "01", "0001", "00001", and "000001" when the preceding digital modulation code that has already been selected terminates with "100";
- selecting any one of the digital modulation codes the first bits of which are "001", "00001", "000001", "0000001", "110", "1110", "11110", and "111110" when the preceding digital modulation code that has already been selected terminates with "011";
  - selecting any one of the digital modulation codes the first bits of which are "110", "1110", "11110", "111110", "01", "0001", "00001" when the preceding digital modulation code that has already been selected terminates with "1000";
- selecting any one of the digital modulation codes the first bits of which are "001", "0001", "00001", "000001", "10", "110", "1110", and "11110" when the preceding digital modulation code that has already been selected terminates with "0111";
  - selecting any one of the digital modulation codes the first bits of which are "110", "1110", "11110", "111110", "011", "001", and "0001" when the preceding digital modulation code that has already been selected terminates with "10000";
  - selecting any one of the digital modulation codes the first bits of which are "001", "00001", "000001", "10", "110", and "1110" when the preceding digital modulation code that has already been selected terminates with "01111";

selecting any one of the digital modulation codes the first bits of which are "110", "1110", "11110", "111110", "111110", "111110", "01", and "001" when the preceding digital modulation code that has already been selected terminates with "100000"; and

- selecting any one of the digital modulation codes the first bits of which are "001", "00001", "000001", "000001", "0000001", "10", and "110" when the preceding digital modulation code that has already been selected terminates with "011111".
- 7. A digital modulation method as claimed in claim 5, wherein said step 4 comprises the procedures of: selecting any one of the digital modulation codes the CDS of which are 0, -2, -4, and -6 when the DSV at the end of the preceding 14-bit digital modulation code that has already been selected is +4 or +2;
- selecting any one of the digital modulation codes the CDS of which are +4, +2, 0, -2, and -4 when the DSV at the end of the preceding 14-bit digital modulation code that has already been selected is 0; and selecting any one of the digital modulation codes the CDS of which are +6, +4, +2, and 0 when the DSV at the end of the preceding 14-bit digital modulation code that has already been selected is -2 or -4;
- 8. A digital modulation method as claimed in claim 5, wherein said digital modulation codes are the codes described in the following Tables 17 and 18.

Table 17 (CDS  $\geq$  0)

_			<u></u>					
5		8-bit	Modulation codes			8-bit	Modulation codes	
	Class	data	beginning	CDS	Class	data	beginning	CDS
			with "0"				with "1"	
			41.44.144444		•			
	]	0	01111110000001	0		0	10000001111110	0
	ļ	2	01111100011000	ŏ		ż	10000011100111	اةا
10		. 3	01111100001100	0		3	10000011110011	١ŏ١
		4	01111100000110	0		4	10000011111001	0
		5	01111100000011	0		8	10000011111100	0
	1	6	01111001110000	0		6	10000110001111	0
		7	01111001100001	0		7 -	10000110011110	
	i	8 9	01111000110001	ŏ		Š	10000111001110	
15		10	01111000011100	ŏ		10	10000111100011	اةا
	1	l ii	01111000011001	. 0		11	10000111100110	Ŏ
	i	12	01111000001110	0		12	10000111110001	0
	1	13	01111000000111	0		13	10000111111000	0
	ł	1 14	01110011110000	0		14 15	10001100001111	
	l	15	01110011001100	ı		16	10001100110011	اةا
20	l	17	01110011000110	ŏ		17	10001100111001	l ŏ l
	j	is	01110011000011	Ŏ		18	.10001100111100	Ŏ
	1	19	01110001111000	0		19	10001110000111	0
	1	20	01110001110001	0		20	10001110001110	0
	1	21	01110001100110	0	1	21	10001110011001   10001110011100	
	Į.	22	01110000111100	8		23.	10001111000011	
25	1	24	01110000111001	١ŏ	l	24	10001111000110	اةا
	1 (A)	2.5	01110000110011	0	1 (8)	25	10001111001100	0
	1	26	01110000011110	9		26	10001111100001	0
		27	01110000001111	0	1	27	10001111110000	
	İ	28	01100111110000	8		28 29	10011000001111	اۃا
	1	30	01100111001100	١٥		30	10011000110011	اةا
30	Í	31	01100111000110	0		31	10011000111001	0
		32	01100111000011	0		32	10011000111100	0
	ŀ	33	01100110011100	0	1	33	10011001100011	0
	ļ	34	01100110011001	0		34	10011001100110	0
		35	01100110001110	0		38	10011001110001	8
	ļ	36	01100110000111	8		36 37	10011100000111	
35	j	38	01100011110001	0		38	10011100001110	ŏ
00		39	01100011100110	Ŏ		39	10011100011001	
		40	01100011100011	0		40	10011100011100	0
	1	41	01100011001110	0	1	41	10011100110001	0
	i	42	01100011000111	0	•	42	10011100111000	9
	1	43	01100001111100	0	1	43	10011110000011	°
40	1	44	01100001110011	١٥	į.	44	10011110001100	١،١
40	1	45	01100001100111	lő	l	46	10011110011000	اةا
	1	47	01100000111110	0	į .	47	10011111000001	0
	}	48	01100000011111	0	1	48	10011111100000	0
	1	49	01111111000001	2	1	49	10000011111110	2
	1	50	01111110011000	2 2	1	50 51	10000110011111	2 2
45	1	51	01111110000110	1 2	1	52	10000111100111	2
45	1	53	01111110000011	2	l .	53	10000111110011	2
	1	54	01111100111000	2		54	10000111111001	2
		55	01111100110001	2		55	10000111111100	2
	1	56	01111100011100	2 2	•	56 57	10001100011111	2 2
	1	57 58	01111100001110	2		58	10001110001111	2
		59	01111100000111	1 2	I	59	10001110011110	2
50		60	01111001111000	2	1	60	10001111000111	2
	1	61	01111001110001	2		61	. 10001111001110	2
	1	62	01111001100110	2	1	62	10001111100011	2
		63	01111001100011	2	1	63	10001111100110	2
		64	01111000111100	2	j	64	10001111110001	2
	1	65	0111100011001	2 2	1	66	10001111111000	2 2
55	1	""	1 21111200110011		1	""	1 .0011000011111	'

Table 17 (CDS  $\geq$  0)

5					,		, 		
	Class	8-bit data	Modulation codes beginning with "0"	CDS	Class	8-bit data	Modulation codes beginning with "1"	CDS	]
10		67 68 69 70 71 72 73	p1111000011110 01111000001111 01110011111000 01110011110001 01110011100110 011100110011110	2222222	·	67 68 59 70 71 72 73	10011000111110 10011001100111 100110011	2 2 2 2 2 2 2 2	
15		75 76 77 78 79	01110001111100 01110001111001 01110001100111 01110001100111 01110000111110	2 2 2 2 2 2 2 2	1 (B)	74 78 76 77 78 79 80	10011100110011 10011100111001 1001111000111 10011110001110 10011110011001 10011110011001	2 2 2 2 2 2 2 2	
20	1 (A)	81 82 83 84 85 86 87	0110011111000 01100111110001 01100111100011 01100111000111 011001110011110 011001110011110	2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2		81 82 83 84 85 86	10011111000011 10011111000110 10011111001100 100111111	2 2 2 2 4	
25		88 89 90 91 92 93	01100110001111 01100011111100 01100011110011 01100011100111 01100011001111 01100011011	222222		87 88 89 90 91 92 93	1100001111110 1100011001111 1100011100111 1100011110011 1100011111001 11000111111	• • • • • • • • • • • • • • • • • • • •	
30		95 96 97 98 99 100	01111111001100 01111111000110 011111110001110 0111111	44444		95 96 97 98 99 100	11001100111110 11001110001111 110011110011110 11001111001110 11001111100011 1100000111111	4 4 4 4 4 4 2	
35		102 103 104 105 106 107 108	01111100111100 01111100111001 0111110011110 01111100011110 011111000111100 011111001111100	4 4 4 4 4 4 4	2 (B)	102 103 104 105 106 107	1100001100111 11000011100111 11000011110011 1100001111100 11000110001111 1100011001111	2 2 2 2 2 2 2 2 2 2 2	
40		109 110 111 112 113 -114 115	01111001110011 0111100011110 01111000011111 011100111111	444444444444444444444444444444444444444	•	109 110 111 112 113 114 115	11000111000111 1100011100011 11000111100011 1100011110001 11000111111	2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2	
45		117 118 119 120 121 122 123	01110011001111 01110001111110 01100111111	****		117 118 119 120 121 122	11001100110011 11001100111001 110011001	2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2	
50		124 125 126 127 128	0110011001111 011011001111110 01111110001111 0111111	4 4 6 6 6		123 124 125 126 127 128 129	110011110011100 11001111000111 110011111001100 11001111100001 1100111111	2 2 2 2 2 0	
55	2 (A)	130 131 132 133	00111111000001 00111110011000 00111110001100 00111110000110	0 0 0		130 131 132 133	11000000111110 11000001100111 11000001110011	0000	
	•	,		- 5	- 1			~ i	

Table 17 (CDS  $\geq$  0)

_			Table		,0	,		
5	Class	8-bit data	Modulation codes beginning with "O"	CDS	Class		Modulation codes beginning with "1"	CDS
10		134 135 136 137 138 139	00111110000011 00111100111000 001111001110001 00111100011100 00111100001110 00111100000111	000000		134 135 136 137 138 139	11000001111100 11000011000111 11000011001110 11000011100011 1100001110001 1100001111000	000000
15		141 142 143 144 145 146	00111001111000 00111001110001 00111001100110 00111001100011 00111000111001	000000	2 (8)	141 142 143 144 145 146	11000110000111 11000110001110 11000110011001 11000110011100 11000111000011	00000
20		147 148 149 150 151 152	00111000110011 00111000011110 00111000001111 00110011111000 00110011100011	000000		147 148 149 150 151 152 153	11000111001100 11000111100001 11000111110000 1100110000111 11001100011001 110011000110001	000000
25	2 (A)	154 155 156 157 158 158 160	00110011001110 00110011000111 0011000111100 0011000111001 00110001100111 00110000111110	0000000		184 185 186 187 188 189 160	11001100110001 11001100111000 1100111000011 1100111000110 1100111001100 1100111100100	0000000
30		162 163 164 165 166	0011111100001 0011111100010 00111111000110 0011111000110 00111110011100	2 2 2 2 2		162 163 164 165 166 167	11001111100110 110011111110001 1100111111	44444
35		168 169 170 171 172 173 174	00111110001110 0011111000111100 001111001111001 00111100111001 0011110001111100011111001111100111110001111	2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2		168 169 170 171 172 173 174 175	11100011110011 11100011111001 11100011011	*****
40		176 177 178 179 180 161 162	00111001111001 001110011100111 00111000111110 001110000111110 0011000111111	2 2 2 2 2 2 2 2 2 2	3 (B)	176 177 178 179 180 181	11100111100110 111001111110001 11100111111	4 4 2 2 2 2 2
45		183 184 185 186 187 188 189	0011001110011 00110011100111 0011001100	2 2 2 4 4 4 4		183 184 185 186 187 188 189	11100001111001 11100001111100 11100011000111 11100011100011 11100011100011 11100011110001	2 2 2 2 2 2 2 2 2 2
50		190 191 192 193 194 195	00111100011111 001110011111110 00110011	14		190 191 192 193 194 195	11100011111000 11100110000111 111001100	2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
55		197 198 199		6 6 6		197 198 199	11100111001100	2 2 2

_			Table	17	(CD	s ≥ 0	)	
5	Class	8-bit data	Modulation codes beginning with "O"	CDS	Class		Modulation codes beginning with "1"	CDS
10	•	200 201 202 203 204 205 206	00011111110000 00011111100001 00011111000110 0001111100011 00011110011100 00011110011001	000000	•	200 201 202 203 204 205 205	11100000001111 11100000011110 11100000110011 11100000111001 11100001100011	0000000
15		207 208 209 210 211 212	00011110001110 00011110000111 00011100111100 00011100111001 00011100100		3 (8)	207 208 209 210 211 212	11100001110001 11100001111000 1110001100011 11100011001100 11100011001100	00000
20	3 (A)	213 214 215 216 217 218 219	00011100001111 00011001111100 000110011	000000		213 214 215 216 217 218 219	11100011110000 11100110000011 111001100	000000
25		220 221 222 223 224 225 226 227	00011111110001 0001111100011 00011111001110 00011111001111 000111100111110 000111100111110	2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2		220 221 222 223 224 225 226 227	11110000001111 1111000001110 1111000011001 1111000011100 11110001100011 11110001100011	2222222
30		228 229 230 231 232 233	00011100011111 00011001111110 00011111100111 00011111001111 000111110011111	2 4 4 4 4 4	4 (B)	228 229 230 231 232 232	11110001111000 11110011000011 11110011000110 11110011100001 11110011110000	2 2 2 2 2 2
35	4 (A)	234 235 236 237 238 239 240 241	00001111111000 00001111110001 0000111100111 00001111001110 0000111000111 000011100011110	00000000		234 235 236 237 238 239 240 241	11110000000111 111100000011100 11110000011000 11110000110001 11110001100001 11110001100001	0000000
40		242 243 244 245 246 247 248	00001100111110 00001100011111 0000111111	2 2 2 2 2	E /n\	243 244 245 246 247 248	11110011100000 11111000000111 11111000011100 11111000111000 1111100111000	2 2 2 2 2 2
45	5 (A)	249 250 251 252 253 254	00000111111100 0000011111001 0000011110011 0000011100111 0000011001111	00000	5 (B)	249 250 251 252 253 - 254	11111000000011 1111100000110 1111100001100 1111100011000 1111100110000	00000
	8 (A)	255	00000011111110	0	6 (B)	255	11111100000001	0

Table 18 (CDS  $\leq$  0)

5			•					<del></del> ,
	Class	8-bit data	Modulation codes beginning with "0"	CDS	Class	8-bit data	Modulation codes beginning with "1"	CDS
10		0 1 2 3 4 5	01111110000001 01111100110000 01111100011000 01111100001100 011111000000	0000000	-	0 1 2 3 4 5 6 7	10000001111110 10000011001111 10000011100111 10000011110011 10000011111001 100001110001111	0000000
15		8 9 10 11 12 13	01111000111000 01111000110001 01111000011100 01111000011001 01111000000	00000		8 9 10 11 12 13	10000111000111 10000111001110 10000111100011 1000011110001 1000011110001	00000
20		14 15 16 17 18 19 20	01110011110000 01110011100001 01110011000110 01110011000011 01110001110001	00000		14 15 16 17 18 19 20	10001100001111 100011000111001 10001100110011 100011001111001 1000111000111100 100011100001110	000000
25	1 (c)	21 22 23 24 25 26 27 28	01110001100110 01110001100011 0111000011100 01110000111001 01110000111001 01110000011110	0 0 0 0	1 (D)	21 22 23 24 25 26 27	10001110011001 10001110011100 1000111100011 10001111001100 10001111001100 10001111100001	0000000
30		29 30 31 32 33 34	01100111110000 01100111100110 01100111000110 01100111000110 0110011100011100 011001100111001	000000		28 29 30 31 32 33	10011000001111 10011000011010 1001100011001 10011000111001 100110001100011	00000
35		35 36 37 38 39 40 41	01100110001110 01100110000111 011000111110001 01100011110001 01100011100011 01100011100011	000000		35 36 37 38 39 40 41	10011001110001 10011001111000 1001110000111 10011100001100 10011100011001 10011100011000	000000
40		42 43 44 45 46 47 48 49	01100011000111 01100001111001 011000011110011 011000011100111 01100000111111	0000002		42 43 44 45 46 47 48 49	10011100111000- 10011110000110 10011110000110 10011110001100 10011111001100 100111111	0000000
45		50 51 52 53 54 55	01111001100900 01111000110000 0111100001100 01111000001100 01111000000	-2 -2 -2 -2 -2 -2		50 51 52 53 54 55	1000001100111 1000001110011 10000001111001 1000001111100 1000001100111	-2 -2 -2 -2 -2
50		56 57 58 59 60 61 62 63	01110011100000 01110011000001 01110001110000 01110001100000 01110000110000 0111000011000 0111000011000	-2 -2 -2 -2 -2 -2		56° 57 58 59 60 61 62 63	10000011100011 10000011100110 10000011110001 10000011111000 10000110000111 10000110001110 100001100111001	-2 -2 -2 -2 -2 -2 -2 -2
55		65 66	01110000001110	-2 -2 -2		64 65 66	10000111000011	-2 -2 -2

Table 18 (CDS  $\leq$  0)

					,	/		
5	Class	8-bit data	beginning	CDS	Class	8-bit data	Modulation codes beginning	CDS
10		67 68 69 70 71 72 73	with "0" 01100111000001 0110011001100 01100110	-2 -2 -2 -2 -2 -2		67 68 69 70 71 72 73	with "1"   10000111100001   10000111110000   10001100000111   10001100001100   1000110001	-2 -2 -2 -2 -2 -2 -2
15	1 (C)	74 75 76 77 78 79 80	01100011001100 01100011000110 01100011000011 01100001110001 01100001100110 0110000110011			74 75 76 77 78 79 80	10001100111000 10001110000011 10001110000110 10001110001100 10001110011000 10001111000001	-2 -2 -2 -2 -2 -2
20		81 82 83 84 85 86	0110000011100 0110000011001 0110000011001 011000000	-2 -2 -2 -4 -4	1 (D)	81 82 83 84 85 86 87	10011000000111 10011000001110 10011000011001 10011000011100 10011000110001 10011000110001	******
25		88 89 90 91 92 93	0011100110000 0011100011000 0011100001100 0011100001100 0011100000110 00111000000	******		88 89 90 91 92 93	10011001110000 10011100000011 10011100000110 1001110001100 10011100011000 100111100110000	-22222
30	2 (C)	95 96 97 98 99 100	00110011000001 001100011100001 00110001100001 00110000110001 00110000011100			95 96 97 98 99 100	10000000110011 10000000111001 1000000011100 1000000	-4 -4 -4 -4
. 35		102 103 104 105 106 107	0011110011000 00111100011000 00111100001100 00111100000110 00111100000011 00111001100	******		102 103 104 · · · 105 106 107	10000011000011 10000011000110 10000011001100 10000011100001 1000001110000 10000110000011	
40		109 110 111 112 113 114 115	00111000111000 00111000110001 0011100001100 0011100001110 00111000001110 001110011110000	*******		.109 110 111 112 113 114	10000110001100 10000110011000 10000111000001 10000111000001 100011000000	
<b>4</b> 5		116 117 118 119 120 121 122	00110011100001 00110011001100 001100110	******		116 117 118 119 120 121 122	10001100011000 10001100110000 1000111000000	-6 -6 -6 -6
50		123 124 125 126 127 128 129	00110001100011 00110000111100 0011000011001 0011000011001 00110000011110 0011000000	******		123 124 125 126 127 128	10011000110000 10011001100000 100111000000	-4 -4 -6 -6 -6
55		130 131 132	00111111000001	0	2 (D)	130 131 132	11000000111110 11000001100111 11000001110011	0

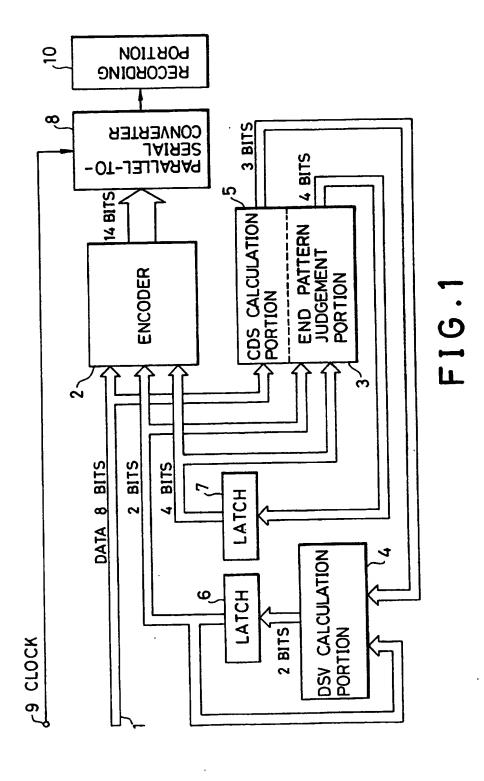
Table 18 (CDS  $\leq$  0)

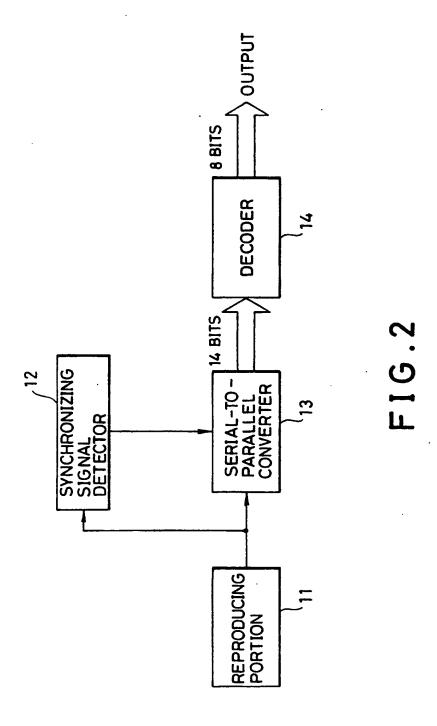
5								
		8-bit	Modulation codes				Modulation codes	
	Class	data	beginning	CDS	Class	data	beginning	CDS
•			with "0"				with "1"	
		133	00111110000110	0	'	133	11000001111001	0
		134	00111110000011	ŏ		134	11000001111100	0
10		135	00111100111000	0		135	11000011000111	0
		136	00111100110001	0		136	11000011001110	0
	•	137	00111100011100	0		137	11000071100011	0
	l	138	00111100011001	0		138 139	11000011100110	0
	!	139	00111100001110   00111100000111	0		140	11000011110001	ŏ
	l	141	00111001111000	ŏ		141	11000110000111	ŏ
15	l	142	00111001110001	. ŏ		142	11000110001110	ŏ
13		143	00111001100110	Ö		143	11000110011001	ŏ
		144	00111001100011	0		144	11000110011100	0
	l	145	00111000111100.	0		145	11000111000011	0
		146	00111000111001	0		146	11000111000110	0
	0 (0)	147	00111000110011	0		147	11000111001100	0
	2 (C)	148	00111000011110	0		149	11000111100001	ŏ
20	İ	150	00110011111000	l ŏ l		150	11001100000111	ŏ
		151	00110011110001	ŏ	·	151	11001100001110	0
	l	152	00110011100110	0		152	11001100011001	0
	1	153	00110011100011	0		153	11001100011100	o l
	1	154	00110011001110	.0	ĺ	154 155	11001100110001	0
		155	00110011000111	.0		156	11001110000011	ŏ
25	1	157	00110001111001	lŏ	2 (D)	157	1 11001110000110	ŏ
•	1	158	00110001110011	Ĭŏ	* (0)	158	11001110001100	0
	ł	159	00110001100111	0	l	159	11001110011000	0
	1	160	00110000111110	0	i	160	11001111000001	0 1
	1	161	00110000011111	10		161	11001111100000	0
		162	00110000011001	-4		162 163	11000000011110	-2 -2
30		163 164	00110000001110	-4	i	164	11000000110011	-2
	<u> </u>	165	00011110000001	1-2	1	165	11000000111100	-2
	1	166	00011100110000	-4	l	166	11000001100011	-2
	1	167	00011100011000	-4		167	11000001100110	-2
		168	00011100001100	-4		168	11000001110001	-2
	ł	169	00011100000110	1-4		169	11000001111000	-2
35	1	170	00011100000011	-4	l	170	11000011000011	-2
35	1	171	-00011001110000	1-4	į.	171	11000011000110	-2 -2
	1	172	00011001100001	-4	1	173	11000011001100	-2
	1	174	00011000110001	-4	į .	174	11000011110000	-2
	L	175	00011000011100	-4	l	175	11000110000011	-2
	1	176	00011000011001	-4	l	176	11000110000110	-2
	1 0 /01	177	00011000001110	-4	1	177	11000110001100	-2
40	3 (C)	178	00011000000111	1-4	1	178	11000110011000	-2
	1	179	00011111100000	-2		179	11000111000001	-2 -2
	1	180	00011111000001	-2		181	11001100000011	-2
	1	182	00011110001100	-2		182	11001100000110	-2
	1	183	00011110000110	<b>]-2</b>	1	183	11001100001100	-2
	1	184.	00011110000011	2	1	184	11001100011000	-2
45	[	185	00011100111000	-2	Ì	185	11001100110000	-2
	[	186	00011100110001	-  -2	1	180	11001110000001	-4 -4
	1	187	00011100011100	-2  -2	ſ	187	11000000011001	=
	1	188	00011100011001	-2	I	189	11000000110001	-4
	1	189	00011100000111	-2	1	190	11000000111000	-4
	1	191	00011001111000	-2	I	191	11000001100001	-4
50	1	192	00011001110001	-2	1	192	11000001110000	-4
	1	193	00011001100110	-2	1	193	11000011000001	-4
	1	194	00011001100011	-2	l .	194	11000011100000	- 4
	1	195	00011000111100	-2	1	195	110001100000001	-4
		196	00011000111001	-2	1	196	11001100000001	-6
	1	197	00011000110011	-2  -2	1	198	1100000011000	-6
ee	1	199	00011000001111	-2	1	199	11000001100000	ا ہ- ا
55	•	,,	1	1 -				لستسا

Table 18 (CDS  $\leq$  0)

Class   data   beginning   with   00     Class   data   beginning   with   00     Class   data   beginning   with   00	5		8-bit	Mark landa and		1	<del></del>	1	
	_	Class		i i	CDS	Class			CDC
10				with "0"					CDS
10				00011111110000					0
15			202	00011111001100					
15   205   206   207   207   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208   208	10	1			0	ł	203		
15   2006   0.0011110011001   0   2006   111000011100110   0   2007   11100001110011   0   2008   0.0011100111100   0   2008   11100001110010   0   2008   11100001110010   0   2008   11100001110010   0   2008   11100001110010   0   2008   11100001110010   0   2008   11100001110010   0   2008   11100001110010   0   2008   111000011000110   0   2008   111000011000110   0   2008   111000011000110   0   2008   111000011000110   0   2008   111000011000110   0   2008   111000011000110   0   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008   2008		1		00011110000011					
15   3 (C)   208   00011110000111   0   208   11100001110000   0   209   1100001110000   0   211   1100001111000   0   211   1100011000				, 00011110011001	0		206	11100001100110	
3 (C)   209   00011100111100   0   209   11100011000011   0   211   00011100111				00011110001110					
20	•	3 (C)		00011100111100	O		209		
20	15	1		00011100111001				11100011000110	0
20				00011100011110	_			11100011001100	
20			2 1 7	00011100001111				11100011110000	Ŏ
20				00011001111001					
218	20	1		00011001110011	ŏ	3 (0)	216	11100110001100	
20 000111001001 -2 221 11100000011001 -2 222 1110000011001 -2 223 00001111001100 -2 223 11100000011001 -2 223 0000111001100 -2 223 11100000011001 -2 223 1110000011001 -2 223 11100000110001 -2 223 1110000110001 -2 224 0000111001100 -2 225 1110000110001 -2 225 1110000110001 -2 226 00001110011100 -2 226 1110000110000 -2 227 00001110001110 -2 227 1110001100000 -2 228 000011000111 -2 228 000011000111 -2 228 11100001100000 -2 228 000011000111 -2 228 11100001100000 -2 228 00001100011100 -2 228 11100001100000 -2 228 11100001100000 -2 228 00001100111001 -2 228 11100000110000 -2 228 11100001100000 -2 228 11100001100000 -2 228 11100001100000 -2 228 1110000011000 -4 228 0000110001111 -2 228 1110000011000 -4 235 0000110001111 -2 235 1110000001100 -4 235 0000110001111 -2 235 1110000001100 -4 235 0000111100011 0 235 1110000001100 0 235 1110000001100 0 235 111000000110 0 235 111000000110 0 236 111000001100 0 236 111000001100 0 237 0000111100011 0 237 1110000001100 0 240 0000111000111 0 242 0000111000111 0 242 00001100011	20		218	00011001100111		0 (0)			
221 00001111001001 -2 221 11100000011001 -2 223 000011110010100 -2 222 11100000011001 -2 223 00001110010100 -2 223 1110000011000 -2 224 11100000110001 -2 225 00001110011001 -2 225 00001110011001 -2 225 00001110011001 -2 225 1110000110001 -2 226 0000110011100 -2 225 11100001100001 -2 226 00001100011100 -2 226 1110000110000 -2 227 00001100011100 -2 228 00001100011110 -2 228 1110001100000 -2 229 00001100111100 -2 229 1110000110000 -2 229 1110000011000 -2 229 1110000011000 -2 229 1110000011000 -2 229 1110000011000 -2 229 1110000011000 -4 223 00001100011110 -2 223 1110000011000 -4 223 00001100011110 -2 223 1110000011000 -4 223 00001100001110 -2 223 1110000011000 -4 223 00001100001110 -2 223 1110000011000 -4 223 000011100001 -2 223 1110000011000 -4 223 000011110001 0 223 1110000011000 -4 223 1110000011000 -4 223 1110000011000 -4 223 1110000011000 -4 223 1110000011000 -4 223 1110000011000 -4 223 1110000011000 -4 223 1110000011000 -4 223 1110000011000 -4 223 1110000011000 -4 223 1110000011000 -4 223 1110000011000 -4 223 1110000011000 -4 223 1110000011000 -4 223 1110000011000 -4 223 1110000011000 -4 223 1110000011000 -4 223 1110000011000 -4 223 1110000011000 -4 223 1110000011000 -4 223 1110000011000 -4 223 1110000011000 -4 223 1110000011000 -4 223 1110000011000 -4 223 1110000011000 -4 223 1110000011000 -4 223 1110000011000 -4 223 1110000011000 -4 223 1110000011000 -4 223 1110000011000 -4 223 1110000011000 -4 223 1110000011000 -4 223 1110000011000 -4 223 1110000011000 -4 223 1110000011000 -4 223 1110000011000 -4 223 1110000011000 -4 223 1110000011000 -4 223 1110000011000 -4 223 1110000000000 -4 223 111000000000000 -4 223 11100000000000000000000000000000000				00011000011111	0	1	219	11100111100000	
222 00001111001100 -2 223 1110000001100 -2 224 000011100011 -2 225 00001110011100 -2 225 00001110011100 -2 225 00001110011100 -2 225 00001110011100 -2 225 11100001100001 -2 225 00001110011100 -2 225 11100001100001 -2 225 11100001100001 -2 225 0000110001110 -2 225 11100001100000 -2 227 00001100101100 -2 228 11100011000001 -2 229 0000110011100 -2 229 1110011000001 -2 229 0000110011100 -2 229 1110011000001 -2 229 1110011000001 -2 229 1110011000001 -2 229 111001000001 -2 229 111001000001 -2 229 111001000001 -2 229 111001000001 -2 229 111001000001 -2 229 111001000001 -2 229 1110000011000 -4 225 0000110011100 -2 225 1110000011000 -4 225 0000111001100 0 225 1110000011000 -4 225 0000111110001 0 225 1110000011000 -4 225 000011110001 0 225 1110000011000 0 225 111000001100 0 0 225 0000111000111 0 0 225 111000011000 0 0 225 0000110011110 0 0 225 1110000110000 0 0 225 000001100011		1	221	0000111110000				11100000001110	
25		1		00001111001100	-2		222		
30  4 (C) 225 00001110011100 -2 226 11100001100001 -2 227 000011100111100 -2 228 11100011000001 -2 229 00001100111100 -2 229 11100011000001 -2 229 11100110000001 -2 229 11100110000001 -2 229 11100110000001 -2 229 11100110000001 -2 229 11100110000001 -2 229 11100110000001 -2 230 0000110011110 -2 230 0000110011110 -2 230 0000110011110 -2 231 1110000011000 -4 231 000011001111 -2 232 1110000011000 -4 233 0000110011110 -2 233 1110000011000 -4 235 0000111110010 0 235 0000111110010 0 235 0000111110010 0 235 1110000011000 -4 237 0000111100111 0 0 235 1110000011000 -4 237 000011100111 0 0 235 111000001100 0 235 111000001100 0 235 111000001100 0 0 236 1111000001100 0 0 237 000011100111 0 0 237 111000001100 0 0 237 000011100111 0 0 237 111000001100 0 0 237 000011100111 0 0 241 0000110011 0 0 241 00001100111 0 0 241 00001100111 0 0 241 00001100111 0 0 241 0000110011 0 0 245 000011100111 0 0 245 0000011100111 0 0 245 000001100011 -2 245 0000011100111 0 0 245 000001100011 -2 246 000001100011 -2 246 000001100011 -2 247 0000011100111 0 0 250 0000011110011 0 0 250 0000011110011 0 0 250 0000011110011 0 0 250 0000011110011 0 0 250 0000011110011 0 0 250 0000011110011 0 0 250 0000011110011 0 0 250 0000011110011 0 0 250 0000011110011 0 0 250 0000011100111	25	1 1	224	00001111000110					
30	20	1 1		00001110011100	-2	,	225		
4 (C)		1		00001310031003				11100001110000	
30		1 1		.00001110000111	-2			111000111000001	
30		4 (0)		00001100111100				11100110000001	-2
35   232   000011000011110   -2   232   11100000110000   -4   -4   -4   -2   -2   -2   -2   -4   -4	30	''''		00001100110011					· ·
35   234   00001111111000   0   235   11110000001111   0   0   0   0   0					-2	İ	232	11100000110000	-4
35		1 1		00001111111000					
35   237   0000111100011   0   238   11110000011001   0   0   0   0   0				00001111110001		ĺĺ		11110000001110	-
35			237						
40	35	]		00001111001110	Ŏ	- 1	238		-
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$		l i	240	0000111000111					- 1
40				00001110001111	Ŏ	4 (D)			· ·
40				00001100111110		}			Ŏ
45				00000111111000				11110011100000	
5 (C) 247 00000111000111 -2 247 11110000110000 -2 248 00000110001111 0 0 250 11111000001100 0 0 250 1111100000110 0 0 250 00000111111001 0 0 250 1111100000110 0 0 250 00000111100111 0 0 250 00000111100111 0 251 0000011100111	40	i i		00000111100011				11110000001100	-2
45			247	00000111000111		1		11110000011000	
45		5 (C)		00000110001111	-2 L		248	11110001100000 i	-2
45 251 00000111110011 0 5 (D) 251 1111100001100 0 0 252 0000011100111			250	00000111111001		i			
45 252 0000011100111 0 252 11111000011000 0 0 253 11111000110000 0 0 254 11111001100000 0				00000111110011	0	5 (D)	251	11111000001100	Ö
5 (C) 255 00000110011111 0 254 11111001100000 0	45		253	00000111001111					
0 (c) 255   000000011111110   0   8 (D)   255   111111100000001   0		F (C)		00000110011111	_ف		254	11111001100000	
		0 (0)	433	00000011111110	<u>•</u> ]	8 (D)	255	11111100000001	0

50





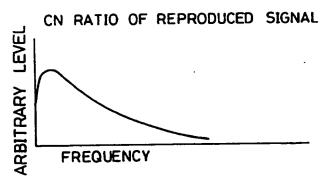


FIG.3A

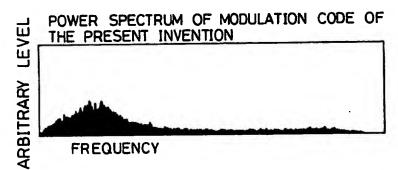


FIG.3B

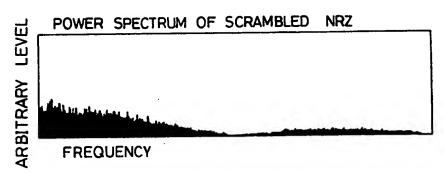


FIG.3C

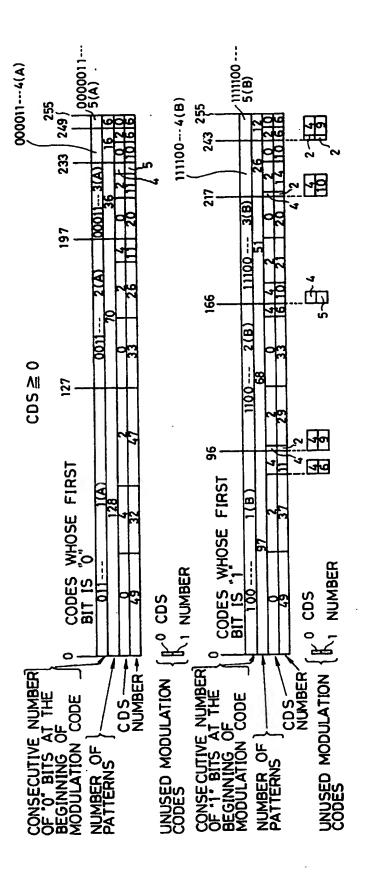


FIG.4

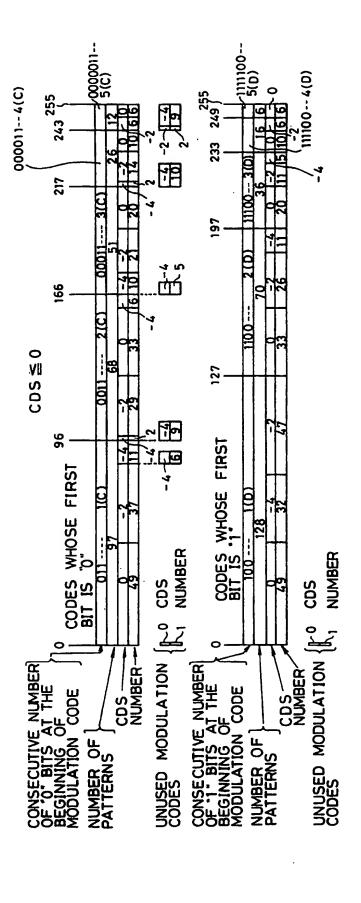
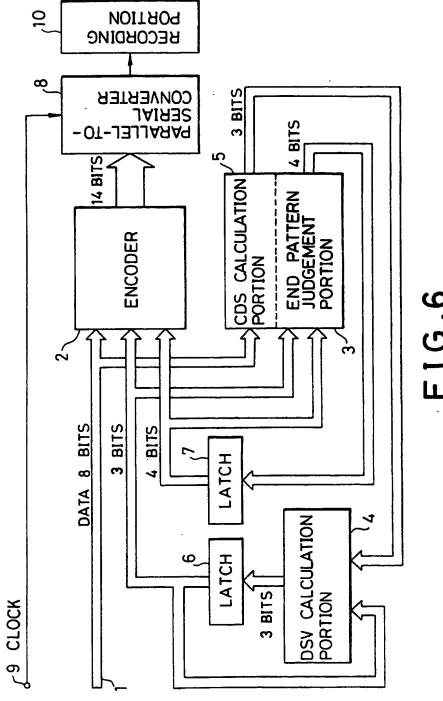
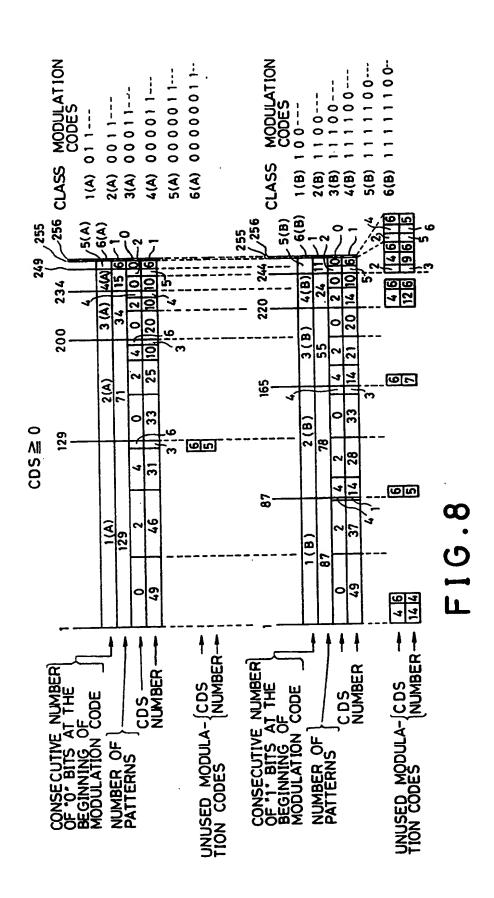


FIG.5



CALCULATE DSV AT THE END OF THE PRECEDING MODULATION CODE JUDGE THE END PATTERN OF THE PRECEDING MODULATION CODE SELECT TABLE OF THE MODULATION CODE · WHEN DSV = 0 AND THE END PATTERN OF THE PRECEDING CODE IS ANY ONE OF "...1100", "...11000", "...110000", "...1100000", AND
"...001", OR WHEN DSV < 0, SELECT TABLE 17 -53 WHERE CDS  $\geq 0$ . WHEN DSV = 0 AND THE END PATTERN OF THE PRECEDING CODE IS ANY ONE OF "...110", "...0011", "...00111", "...001111", AND "...0011111", OR WHEN DSV > 0, SELECT TABLE 18 WHERE CDS  $\leq 0$ . SELECT A MODULATION CODE ACCORDING TO THE END PATTERN OF THE PRECEDING MODULATION CODE SELECT A MODULATION CODE FROM THE CLASSES 1(A) - 6(D) OF TABLES 17 AND 18 ACCORDING TO THE END PATTERN OF THE PRECEDING MODULATION CODE. WHEN TWO OR MORE MODULATION CODES ARE SELECTED, SELECT A MODULATION CODE WHICH GIVES DSV THE ABSOLUTE VALUE OF WHICH IS MINIMUM. WHEN TWO OR MORE MODULATION CODES HAVE THE SAME MINIMUM DSV, SELECT A MODULATION CODE THAT SATISFIES THE FOLLOWING REQUIREMENTS: WHEN DSV < 0, SELECT A MODULATION CODE WHOSE ۶6ء FIRST BIT IS "1"; WHEN DSV > 0, SELECT A MODULATION CODE WHOSE FIRST BIT IS "0"; AND WHEN DSV = 0, SELECT A MODULATION CODE WHOSE FIRST BIT IS OPPOSITE TO THE LAST BIT OF THE PRECEDING MODULATION CODE.

FIG.7



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